THE UNITED STATES
STRATEGIC BOMBING SURVEY

JAPANESE MERCHANT SHIPBUILDING

Military Supplies Division

January 1947

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This report was written primarily for the use of the U. S. Strategic Bombing Survey in the preparation of further reports of a more comprehensive nature. Any conclusions or opinions expressed in this report must be considered as limited to the specific material covered and as subject to further interpretation in the light of further studies conducted by the Survey.

FOREWORD

The United States Strategic Bombing Survey was established by the Secretary of War on 3 November 1944, pursuant to a directive from the late President Roosevelt. Its mission was to conduct an impartial and expert study of the effects of our aerial attack on Germany, to be used in connection with air attacks on Japan and to establish a basis for evaluating the importance and potentialities of air power as an instrument of military strategy for planning the future development of the United States armed forces and for determining future economic policies with respect to the national defense. A summary report and some 200 supporting reports containing the findings of the Survey in Germany have been published.

On 15 August 1945, President Truman requested that the Survey conduct a similar study of the effects of all types of air attack in the war against Japan, submitting reports in duplicate to the Secretary of War and to the Secretary of the Navy. The officers of the Survey during its Japanese phase were:

Franklin D'Olier, *Chairman.*
Paul H. Nitze,
Henry C. Alexander, *Vice-Chairmen.*
Harry L. Bowman,
J. Kenneth Galbraith,
Rensis Likert,
Frank A. McNamee, Jr.,
Fred Searls, Jr.,
Monroe E. Spaght,
Dr. Lewis R. Thompson,
Theodore P. Wright,
Directors.
Walter Wilds, *Secretary.*

The Survey's complement provided for 300 civilians, 350 officers, and 500 enlisted men. The military segment of the organization was drawn from the Army to the extent of 60 percent, and from the Navy to the extent of 40 percent. Both the Army and the Navy gave the Survey all possible assistance in furnishing men, supplies, transport, and information. The Survey operated from headquarters established in Tokyo early in September 1945, with subheadquarters in Nagoya, Osaka, Hiroshima and Nagasaki, and with mobile teams operating in other parts of Japan, the islands of the Pacific, and the Asiatic mainland.

It was possible to reconstruct much of wartime Japanese military planning and execution, engagement by engagement, and campaign by campaign, and to secure reasonably accurate statistics on Japan's economy and war-production, plant by plant, and industry by industry. In addition, studies were conducted on Japan's over-all strategic plans and the background of her entry into the war, the internal discussions and negotiations leading to her acceptance of unconditional surrender, the course of health and morale among the civilian population, the effectiveness of the Japanese civilian defense organization, and the effects of the atomic bombs. Separate reports will be issued covering each phase of the study.

The Survey interrogated more than 700 Japanese military, government, and industrial officials. It also recovered and translated many documents which not only have been useful to the Survey, but also will furnish data valuable for other studies. Arrangements have been made to turn over the Survey's files to the Central Intelligence Group, through which they will be available for further examination and distribution.

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I. SUMMARY AND CONCLUSIONS

The Effort to Meet the Demand for Ships

Beginning with the China incident in 1937, the Japanese economy was constantly and increasingly in need of more and more merchant ships. With the outbreak of war in December 1941, Japan began to suffer ship losses at a steadily increasing rate which her naval and air forces were unable to check.

Not until the war had been in progress a full year did the Japanese bring themselves to concentrate on merchant shipbuilding as if their whole economic and military position depended, as it did, on the adequacy of the merchant marine. The largest commercial shipyards had been preoccupied with the heavy naval ship construction program and little had been done to expand or modernize established yards or to build new ones.

The 12 major commercial yards, which accounted for about three-fourths of the total work done on ships in all the yards during the war, had been well established custom shipbuilders before the war—building and repairing both merchant and naval ships to order with no great premium on volume production and employing the conventional shipbuilding techniques of the 20s and 30s. Shortly after war was declared, the necessity for standardization of ship design was recognized, but the 12 types adopted were little more than official sanction for the more or less uniform ship designs developed in various shipyards.

When the navy, which had assumed control and responsibility for shipbuilding from the Communications Ministry, initiated a genuine effort to expand the volume of shipbuilding, the number of ship types was reduced to seven and several new yards, designed to produce some one type exclusively, were started. As the pressure for more shipping increased, an extensive program of small wooden ship construction was laid out but did not get well under way until the spring of 1943.

The Japanese were confronted with a great increase in demand for petroleum transportation after the outbreak of war. The conduct of the war brought about a large increase in petroleum requirements at home which could only be met by transportation over long distances as from Singapore and the NEI to Japan. Inasmuch as Japan had relied heavily, before the oil embargo by the Allies, on imports in foreign bottoms from outside Greater East Asia, her supply of facilities for overseas oil transport was inadequate to meet the demand for oil transportation. Hence, there existed a great demand for the creation of additional tanker tonnage.

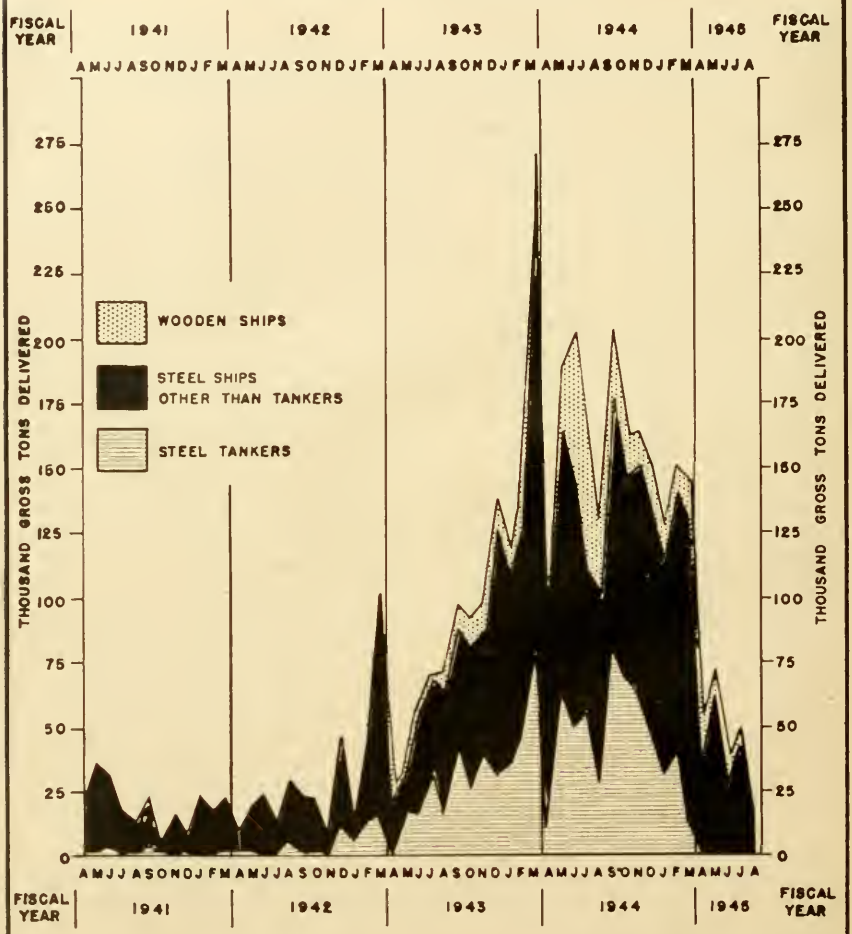
More than 400,000 tons of cargo ships were converted into tankers during the fiscal years 1941 and 1942 and almost 1,000,000 tons of new tankers were built during the war, mostly in 1943 and 1944. The Japanese were never able to provide enough transportation for petroleum products to meet the demands, however, in spite of the delay in the incidence of effective Allied attacks on tankers.

Tanker deliveries met schedules better than other types of merchant ships because of the higher priority assigned to tankers from December 1942 to January 1945. The priority was implemented by the assignment of tanker construction to what were considered the most reliable shipyards. When it became apparent in the spring of 1944 that production schedules generally would not be met, previously scheduled cargo ship production was rescheduled for completion as tankers. It was not until it was considered no longer a worthy risk to send tankers to the south that efforts to meet the demand for new tankers ceased. That decision was made in January 1945.

The monthly tonnage deliveries of steel merchant ships other than tankers, of steel tankers and of all wooden ships are shown on Chart 1, page 2.

CHART I MONTHLY GROSS TONNAGE DELIVERIES OF WOODEN SHIPS, STEEL TANKERS AND OTHER STEEL SHIPS

APRIL 1941 — AUGUST 1945



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JAPANESE MERCHANT SHIPBUILDING

CHART 1

The volume of both ship deliveries and economic input increased rapidly throughout 1943. The lag in fluctuations in the rate of delivery behind corresponding fluctuations in the rated economic input averaged about 2 months. The steel ship producers operated on a peak plateau of production effort from January through October 1944 averaging about 134 million yen input per month. Ship deliveries for the same length period beginning and ending 2 months later averaged about 147,000 gross tons per month. The period of peak activity in wooden ship construction lasted from November 1943 through June 1944 during which time monthly input averaged about 22,000 yen. Wooden ship deliveries for the corresponding period of delivery averaged about 27,000 gross tons per month.

Causes of the Failure

In spite of the strenuous efforts and greatly expanded volume of merchant ship production during the war, new tonnage never exceeded 45 percent of the sinkings in any one year. The greatest single cause of the failure to maintain an adequate merchant marine was the Japanese' failure to prevent wholesale sinkings. The shipbuilding industry had an impossible task.

The basic limitations of the low skill level of the average Japanese workman, the cramped quarters occupied by the shipyards, the lack of heavy duty cranes and equipment, and the unimaginativeness of Japanese industrial engineering and management committed wartime shipbuilding techniques very largely to the low volume traditional methods which were only partially offset by the simplification and economy of design (adopted at the expense of speed and seaworthiness) of the standard ship types put into production.

Once the decision was made to expedite merchant ship construction, heavy naval ship construction was curtailed, and the yards were expanded to permit the rapid increase in the volume of merchant shipbuilding. Before the full capacity of the expanded yards was realized, however, the whole program was overtaken by the over-all shortage of steel in Japan. Production was maintained through the peak period by drastic cuts in steel priorities to activity considered less essential and by drawing down on steel stocks within the steel industry materials pipe-line and steel inventories in the shipyards. These temporary expedients were exhausted by the end of October 1944, and beginning in November a precipitous decline in the volume of ship construction set in. Throughout the period of peak production the extent to which employment had been expanded and average man-hours per employee increased indicates that shipbuilding was under some strain for labor power but was not suffering seriously for the lack of it.

Throughout 1945 the merchant ship construction index continued to fall off at such a rapid rate that production at levels higher than those actually attained could easily have been sustained with the steel stocks reported on hand at the end of the war. Production was suffering from the effects of bombing.

The Effects of Air Attack

Between March 1945 and the end of the war, about one-fourth of the floor space in the commercial shipyards was destroyed by air attacks. Most of the damage was done by direct hits or spreading fires started by the IB urban area attacks. Some damage was done by HE attacks directed at nearby targets. Only one multiplane attack was directed at a shipyard as such, however, during the entire air campaign against the home islands. Most of the 17 shipyards which lost more than 10 percent of their floor space to attack before the end of June suffered less than a 50 percent loss. Nevertheless, production in these yards took a substantial cut from which it never recovered before the end of the war. In the meantime, other yards located in these same cities but undamaged by the area attacks were able to continue production as well or better than other undamaged yards elsewhere in Japan even though the average employment and man-hours fell off to about the same degree as in the damaged yards. The loss of production following the air attacks is, therefore, associated with the demoralization and disorganization of shipyard activities caused by damage to facilities in the shipyards. The Japanese were unable to restore such facilities or to reorganize procedures so that production could be continued without them.

Sufficient additional damage had been inflicted on the shipyards between the end of June and the end of the war that, judged by the effects of the earlier attacks, shipyard activity could have continued only on a rapidly declining scale if the war had been continued.

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In fact the degree of interference with production obtained from the comparatively light damage suggests that an earlier attack on shipyards, particularly those located near the mine fields that were sown by air, would have speeded up the operation in the closing phases of the war of the primary over-all factor in Japan's downfall—her loss of merchant ships.

Scope and Sources of the Report

The analysis of the effects of air attack on Japanese merchant shipbuilding requires first an analysis of the shipbuilding effort before bombing began so that the effects thereof can be seen in the light of other factors affecting the final result. The commercial shipyards of Japan, which built and repaired substantially all of the merchant ships, were also heavily engaged in the construction and repair of naval ships. In some respects, therefore, the analysis deals with the commercial shipyards as a whole rather than exclusively with work on merchant ships. To the extent to which data were available on Japanese operated shipyards outside of Japan proper, they are included. That material is confined to what was available in Japan after the end of the war and is therefore incomplete. This is not a serious shortcoming so far as the total picture is concerned, however, as the ship production thus omitted is known to have been a very small percentage of total ship production.

All references to years in this report are to the official Japanese fiscal year beginning 1 April of the same calendar year unless otherwise specified in the context.

The primary source material for this report is the collection of reports submitted by each of 57 Japanese commercial shipyards to the Bombing Survey in reply to the questionnaire, shown in Appendix 6, prepared by this section of the USSBS and circulated to the shipyards through the General Maritime Board of the Transportation Ministry. The answers from 50 of the yards were substantially complete. Other important sources include one or more interrogation and inspection visits by members of the section to 12 yards in different parts of Japan, interrogations of and reports from the shipbuilding officials of the Transportation Ministry, the Navy Technical Bureau, the Shipbuilding Control Association and Mitsubishi Heavy Industries, and copies of plans and studies made by the Navy Technical Bureau during the war.

This report was prepared under the supervision of Lt. James C. Pettee, USNR, with the assistance of Mr. Norman F. Strachan from the U. S. Maritime Service, Lt. (jg) Robert H. Stern, USNR and 1st Lt. Theodore J. Lettes, AUS.

II. SHIPBUILDING BEFORE THE WAR

Degree of Maritime Self-Sufficiency

Japan became an important maritime nation during the first world war when she was called upon to carry as large a share of trade in the Pacific as possible and to construct the ships required for that purpose. Merchant shipbuilding activity so increased in that period that in 1920 Japanese merchant tonnage afloat had increased more than 600,000 tons over 1919. During the entire war period Japan had nearly doubled her tonnage afloat with ships constructed in her own shipyards. At the end of the war her flag was carried on about 3 million tons of shipping and she carried about four-fifths of her own greatly expanded overseas trade. During the twenties, overseas trade revived from the postwar recession while ship construction dwindled materially with the result that the degree of Japan's maritime self-sufficiency declined considerably. During the thirties, however, she began to regain it and by 1937 Japan carried more than half of her own foreign trade and all of her coastwise, Korean, Manchurian, and Formosan traffic. The fraction of her overseas trade in her own bottoms increased steadily to about two-thirds at the outbreak of the recent war, at which time at least three-fourths of the six million tons afloat was Japanese built.

Japan's tanker position before the recent war was in sharp contrast to the degree of over-all maritime self-sufficiency indicated above. Up to the outbreak of hostilities, she relied heavily on foreign tankers for oil imports. At the time of Pearl Harbor, she had only about 400,000 tons of tankers afloat of which she had delivered about 60 percent from her own yards in the 6 years, 1934 through 1939.

Rate of Ship Construction

Total ship tonnage delivered from Japanese yards dwindled from approximately 600,000 tons annually during the first war to 20,000 or 30,000 tons annually during most of the twenties. During the depression in the early thirties, the government offered subsidies for new construction providing equivalent over-aged tonnage was scrapped. As a result, deliveries reached 85,000 tons in 1931 and averaged more than 100,000 tons annually during the succeeding 4 years.

With the increased commercial and military activity in Manchuria and Korea during the middle thirties, new merchant tonnage deliveries increased rapidly until 1937, the year of the China incident, when deliveries exceeded 440,000 tons. Although the demand for shipping continued to rise as a result of both the military operations in China and the increased industrial production in Japan in support of those operations, merchant ship tonnage deliveries declined steadily after 1937 to 238,000 tons in 1941. A summary of merchant shipping delivered from 1 January 1931 to 15 August 1945 classified by type and by fiscal year of delivery is given in Appendix 2.

Factors Limiting Prewar Construction

The principal cause for the decline in production from 1937 to 1941 was the diversion of more and more shipyard capacity into the construction of naval ships. Between 1938 and 1943 one battleship, six aircraft carriers and five cruisers were built in the commercial shipyards. From 1935 through 1937 the value of work done on ships delivered from the commercial yards was divided 65 percent for merchant ships and 35 percent for naval ships. During the ensuing period of heavy naval construction the division became 56 percent merchant and 44 percent naval.

It was not until 1942 that the gradual rate of yard expansion was enough to permit an increase in the merchant tonnage delivered despite the completion of the heavy naval construction program. Throughout the period 1935 to 1942 the total floor space and total length of building ways increased gradually. In no year, however, did the annual increase amount to 15 percent and the average annual increase was 8.2 percent and 8-1 percent for floor space and way length respectively. Of the total increase in floor space developed during this period, 56 percent was in the 11 commercial shipyards, which yards did over 90 percent of the naval ship construction.

Position of Shipbuilding in the Peacetime Economy

The shipbuilding industry constituted an important part of the Japanese peacetime economy. In 1935 and 1937 the commercial shipyards employed, respectively, 2.3 percent and 3.1 percent of the workers employed in all manufacturing. The value of the merchant ships produced in the years immediately preceding the war was between 5 and 6 percent of the total production of private producers' capital goods, including all expansion in plants and equipment.

III. THE SHIPBUILDING INDUSTRY DURING THE WAR

Position of Shipbuilding in the War Economy

The relative position of merchant shipbuilding in the economy of Japan increased materially during the war, especially during 1943 and 1944. In 1942 the value of the merchant shipping produced had increased to 9 percent of the total production of private producers capital goods. In 1943 and 1944 these ratios were 16 and 14 percent, respectively. The relative share of workers in the commercial shipyards increased more or less steadily throughout the war and in June of 1944 included 8.9 percent of the total engaged in manufacturing. In point of number of workers, shipbuilding in the commercial yards had moved up from tenth among the principal categories of manufacturing in 1930 to third in June 1944, being exceeded on the latter date only by aircraft and ordnance.

Concentration in Number and Size of Shipbuilding Establishments

Substantially all work on merchant ships, both construction, repair and conversion, was done in commercial shipyards. Naval ship construction and repair was divided between the commercial shipyards and the five navy yards in Japan. Many of the commercial yards in Japan carry integration of shipbuilding process to a high degree by manufacturing a large pro-

portion of the ship components used in the yard. Hence, a very considerable proportion of the production of components, including ships engines, is found in the commercial yards.

Data are at hand for 57 individual shipyards that were producing or repairing steel ships over 100 tons during the war. Although several were commonly owned and operated by large industrial interests such as Mitsubishi and Hitachi, each operating yard is considered separately here. When the wartime total of work of all kinds on ships is measured by the excess of the final value of the work over and above the cost of materials, the 57 yards fall into 6 distinct size classes. The 12 shipyards in the first 3 classes are considered to be the major shipyards of Japan and the remainder to be minor. The six classes are constituted as follows:

Class	Value added (million yen)	Number of yards
Major yards:		
1	More than 300	1
2	125–300	5
3	50–125	6
Minor yards:		
4	25– 50	10
5	10– 25	15
6	Less than 10	20
		57

The wartime production and facilities of each shipyard and the division by classes are shown in Appendix 1. The existence of 14 commercial shipyards in addition to the 57 for which data are at hand is indicated by ship construction schedules of the Navy Technical Bureau. Of the 14 it is known that 3 were new yards that never got into production, 7 more were so small that 1 small ship is the only thing scheduled for them and the remaining 4 could have been no more than class 6 yards if they produced all the ships scheduled for them.

The distribution of wartime production and facilities for production among the 6 classes of commercial shipyards is represented by the first 5 bars on Chart 2 page 7. The last four bars on Chart 2 represent the distribution among the shipyard classes of the work done in each of the four principal lines of work on ships: merchant ship construction, naval ship construction, repair and conversion of both types of ships and the production of ship components.

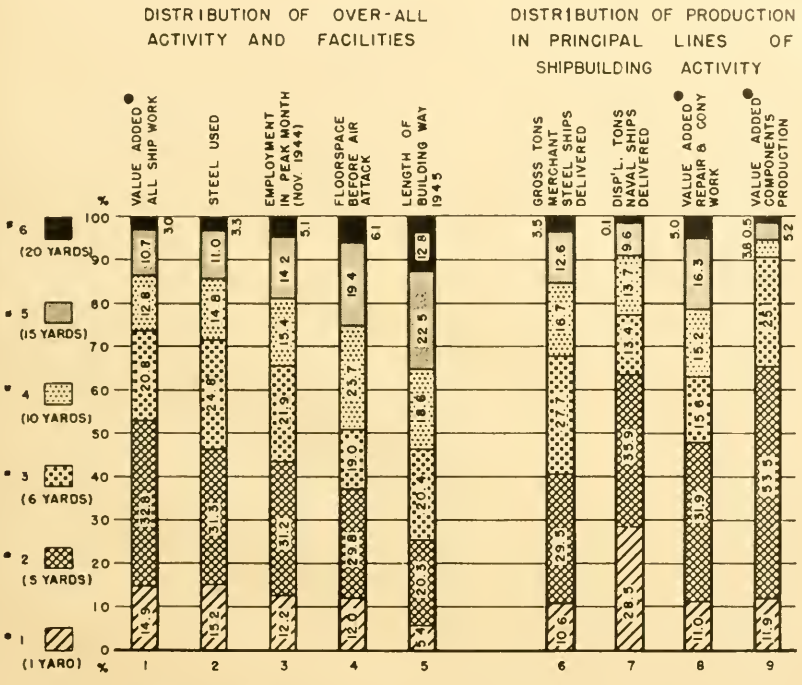
Chart 2 shows that the 12 major yards (classes 1, 2, and 3) performed about 74 percent of the total work on ships during the war, using about 71 percent of the steel, 65 percent of the labor force and about half of the physical plant. This greater relative productivity of the major yards, characteristic also of each of the three major yard classes individually, indicates that greater economy of production was achieved in those yards.

The breakdown of the work done in these shipyards into the four principal lines of work on ships shows that the 12 major yards produced 68 percent of the total gross tonnage of steel merchant ships delivered during the war, the entire tonnage of which came from the commercial yards. These same 12 yards did 64 percent of the ship repair and conversion work done on both merchant and naval ships in the commercial yards the total of which amounted to about 73 percent of the total of such work done in all establishments. The major yards also delivered 78 percent of the naval tonnage delivered by the commercial yards which, in turn, amounted to 60 percent of all naval ship tonnage delivered during the war. At the same time the major yards produced 90 percent of the ship components produced in the commercial yards, measured in terms of value added in production. The relative importance of the components production by the commercial yards as a group is indicated by the fact that 74 percent of the total horsepower of merchant ship engines produced during the war was produced in the commercial yards.

Analysis of the concentration of production in each of the four principal lines of ship work covering all production in the line, whether by commercial shipyard or not is given in Chart 3, page 8. For each line of production on the chart, each horizontal segment shows the cumulative percentage of total wartime output produced by the corresponding number of establishments arranged according to volume of activity.

About 60 percent of the production of naval ships and of merchant ship engines was concentrated among the 5 largest producers of each. That same number of producers of each. That same number of producers of merchant ship tonnage and of ship repair and conversion accounted for about 45 percent of production in those lines. The 10 next most important producers in each line accounted for about 35 percent of the production in the merchant, naval, and repair categories, indicating an

DISTRIBUTION OF PRODUCTION AND FACILITIES AMONG THE SIX PRINCIPAL CLASSES OF COMMERCIAL SHIPYARDS DURING THE WAR



FIGURES WITHIN BARS SHOW THE PERCENT OF THE TOTAL FOR EACH CLASS

●VALUE ADDED IS THE VALUE OF THE FINISHED PRODUCT LESS THE COST OF MATERIALS

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JAPANESE MERCHANT SHIPBUILDING CHART 2

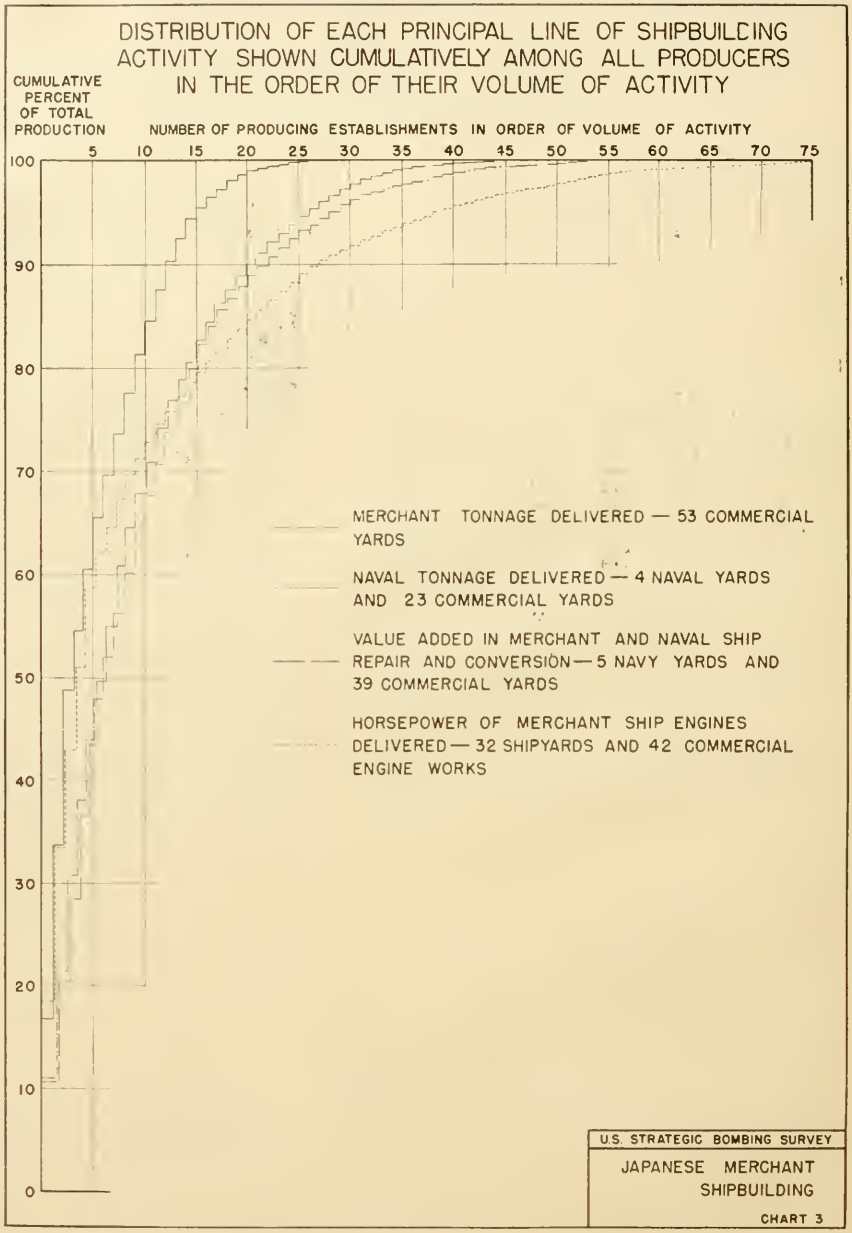
DISTRIBUTION OF EACH PRINCIPAL LINE OF SHIPBUILDING ACTIVITY SHOWN CUMULATIVELY AMONG ALL PRODUCERS IN THE ORDER OF THEIR VOLUME OF ACTIVITY
CUMULATIVE PERCENT OF TOTAL PRODUCTION
NUMBER OF PRODUCING ESTABLISHMENTS IN ORDER OF VOLUME OF ACTIVITY
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
100 90 80 70 60 50 40 30 20 10 0
MERCHANT TONNAGE DELIVERED — 53 COMMERCIAL YARDS
NAVAL TONNAGE DELIVERED — 4 NAVAL YARDS AND 23 COMMERCIAL YARDS
VALUE ADDED IN MERCHANT AND NAVAL SHIP REPAIR AND CONVERSION — 5 NAVY YARDS AND 39 COMMERCIAL YARDS
HORSEPOWER OF MERCHANT SHIP ENGINES DELIVERED — 32 SHIPYARDS AND 42 COMMERCIAL ENGINE WORKS
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CHART 3

important group of middle class producers in those lines. In the production of merchant ship engines, however, the production of the 10 most important producers after the first 5 amounted to only about 20 percent of total production. The remaining 5 percent of naval construction was scattered among 12 establishments, while the remaining 20 percent of production in the other lines was divided among 29 ship-repair establishments, 38 merchant ship producers and 59 producers of ships engines.

Naval ship production was the most highly concentrated phase of shipbuilding. Provision of merchant ship engines was highly concentrated in a few large producers but with a significant balance widely dispersed. Merchant ship production and ship repair and conversion work presented less concentration in the large producers but also less dispersion among small producers.

The extent of common ownership of the various shipyards represents a considerable degree of combination within the industry. Owners of more than one yard and the portion of total wartime production controlled by each were as follows:

Owner	Number of yards	Classes of yards	Percent of total value added produced in yards owned
Mitsubishi	7	1, 2, 2, 4, 4, 4, 5	38.2
Hitachi	5	3, 3, 4, 5, 6	8.2
Kawaminami	3	3, 4, 4	6.5
Japan Steel Tube	3	3, 5, 6	4.2
Kawasaki	2	2, 4	7.2
Harima	2	2, 4	6.3
Uraga	2	3, 5	4.7
Hakodate	2	4, 6	1.7
Amagasaki	2	5, 6	1.1
Urabe	2	5, 6	.5
Sanko	2	6, 6	.3
Total (11 combinations)	32		78.9

The Mitsubishi, Hitachi, and Japan Steel Tube combinations and the single Class 2 yard owned by the Mitsui interests were parts of complex industrial combines. Together they accounted for 57.9 percent of the total value added. The other yards, in combination or singly, were independently owned shipbuilding enterprises.

Geographical Concentration

The commercial shipyards in Japan are highly concentrated geographically. About 70 percent of the yen value added in all shipwork during the war was produced in one of three major industrial areas: Kobe-Osaka, Tokyo Bay and Nagasaki Bay. The major yards in these 3 areas produced almost 60 percent of the total value added in all Japan. An additional 21 percent was produced in yards scattered about in the Inland Sea, three-quarters of which was done in major yards. Only 9 percent came from yards in other parts of Japan. A summary of the geographical concentration of the wartime shipbuilding activity of commercial shipyards is contained in Table 1.

TABLE 1.—*Geographical distribution of wartime shipbuilding activity*[1] *in commercial shipyards*

	Concentrated Area				Dispersed Area				
	Kobe-Osaka	Tokyo Bay	Nagasaki Bay	Total	Inland Sea	Other Japan	Asia mainland	Total	Grand total
Number of shipyards	18	9	3	30	10	15	2	27	57
Percent of total shipbuilding activity	25	23	20	68	21	9	2	32	100
Number of major shipyards	3	4	2	9	3	0	0	3	12
Percent of total shipbuilding activity in major shipyards	18	21	19	58	16	0	0	16	74

[1]Value added in building, repair and conversion of merchant and naval ships and production of ship components.

The concentration was such that nine targets in three areas conducted almost three-fifths of the shipbuilding activity of all commercial yards.

Specialization and Standardization

Comparatively little specialization characterized the work of the Japanese shipyards. Of the total value added in all wartime production in the commercial yards, 10.6 percent was on work not related to shipbuilding The ratio was practically the same for both major and minor yards. The high degree of integration in the shipyards, shown by the fact that 74 percent of merchant ship engine horsepower was produced in the commercial yards, indicated the absence of specialization in that direction.

Most Japanese shipyards divided their efforts between merchant ship construction, naval ship construction and the repair and conversion of either or both kinds of ships. Of the 57 commercial yards, less than 20 yards devoted their entire wartime effort exclusively to one of those three lines of ship work. All yards that did so were minor yards. Five shipyards, four of them major yards, divided their work so evenly among the three lines of work that the value added in no one line of production during the war amounted to 50 percent of the total value of all lines of production in the yard.

A systematic analysis of the degree of spe-

cialization in the commercial shipyards among these three lines of final production is given in Table 2. As an example in interpreting the table, there were 4 major yards in which the value added in the construction of merchant ships ranged between 50 and 70 percent of the total value added in all 3 lines of ship work in the respective yards. The total merchant tonnage delivered by all 9 shipyards in that range amounted to 22.2 percent of the total wartime merchant tonnage delivered.

TABLE 2. *Distribution of commercial shipyards and their production according to the degree of specialization by the yards in the principal lines of final products during the war*

Item	More than 95 percent	70 percent 95 percent	50 percent 70 percent	1 percent 50 percent	0 percent	Uncertain[1]	Total
Merchant ship construction							
Number of shipyards							
Major yards (class 1, 2, 3	1		4	7			12
Large minor yards (class 4, 5	6	4	2	9	3	1	25
Small minor yards (class 6	8	3	3	1	1	4	20
Total shipyards	15	7	9	17	4	5	57
Percentage distribution of merchant tonnage delivered	29.2	4.6	22.2	42.3		1.7	100
Naval ship construction							
Number of shipyards							
Major yards (class 1, 2, 3		1	2	8	1		12
Large minor yards (class 4, 5	2	2	1	5	15		25
Small minor yards (class 6				2	18		20
Total shipyards	2	3	3	15	34		57
Percentage distribution of naval tonnage delivered from commercial yards	2.8	17.0	39.2	41.0			100
Repair and conversion							
Number of shipyards							
Major yards (class 1, 2, 3				12			12
Large minor yards (class 4, 5	1		5	11	7	1	25
Small minor yards (class 6	1	1		8	6	4	20
Total shipyards	2	1	5	31	13	5	57
Percentage distribution of value added in repair and conversion work	5.7	1.4	16.1	76.5		.3	100

[1] Incomplete reports from these five yards itemize only the merchant ships built, some may also have done a small amount of repair work

Aside from the 17 yards devoted almost exclusively to merchant or naval construction, which constitute a special case, there was significantly more specialization among the yards engaged predominantly in naval construction than among those in merchant ship construction. This was the result of the policy on the part of the Navy of preempting for naval construction the bulk of the shipbuilding capacity of two of the largest and most heavily equipped yards in Japan, the Nagasaki yard of Mitsubishi H. I. and the Kobe yard of Kawasaki H. I.

During the war there was much less specialization in repair and conversion than in either line of new ship construction. One of the major yards, Innoshima yard of Hitachi, and seven of the larger minor yards had been more or less exclusively ship-repair yards before the war, but with the great pressure for new ship construction a considerable portion of the effort of all but one, the Chikko yard of Hitachi, was diverted into new ship construction during the war. Ship repair continued to be an important function in all eight of these yards, however.

As a group, the major yards are shown to have been considerably less specialized than the minor yards. The major yards were the older yards in Japan and all-around unspecialized production was characteristic of the low-volume of Japanese peacetime shipbuilding industry. Each shipbuilder felt driven by competition to be equipped to get what shipwork he could regardless of type.

Specialization was carried to a high degree in all of the new shipyards. Of the 17 yards devoted almost exclusively to merchant or naval ship construction, 13 were either built or almost completely rebuilt during or immediately before the war, the 4 yards that were not were small minor yards. In addition to these 13 new yards there were 5 other yards, all minor, built or rebuilt during or immediately before the war. Four of these were in the group of moderately specialized yards (70–95 percent), and one was among the slightly specialized yards (50–70 percent). The latter and one of the other four actually were more highly specialized than is indicated, inasmuch as they did all of their merchant production in the early years of the war and thereafter concentrated exclusively on naval construction.

A factor of major importance in the increase of the volume of merchant ship tonnage was the standardization of ship design. Even before the outbreak of the war some yards had developed their own designs and produced several sister ships according to a standard set of specifications. With a view to standardizing production techniques and facilitating centralized administration of ship production the transport ministry established an official schedule of standard wartime steel merchant vessels in the spring of 1942. Several of the designs developed in the private yards were adopted with slight alteration in the official standard ship program.

The first official schedule included 6 dry cargo types varying from 530 to 6,400 gross tons and designated types A to F, respectively. Also included were one 5,300-ton ore carrier designated type K, 3 tanker types designated TL, TM, and TS ranging from 1,020 to 10,000 tons, a 9,600-ton transport called type M, and a railroad car ferry of 2,800 tons designated type W. Soon after jurisdiction over merchant ship construction was transferred to the Navy Technical

Bureau in the summer of 1942 that unit modified the original official schedule by discontinuing types B, C, F, and K and substituting type TE for TS. Extensive changes in specifications of the six remaining types called for more angular styling of the hull to facilitate production as well as weaker construction; for example, wider spacing for members and elimination of double bottoms, and lighter engines to conserve materials and facilitate production. Significant sacrifice in speed and durability was made in the interest of increased production. The great bulk of wartime ship construction was built according to the specifications of this program.

By the end of 1944 the Navy Technical Bureau established a new set of ship designs improving the lines of the hull and increasing the size of the engine. The change was intended to improve the ships' chances of eluding submarines even if the rate of construction were reduced. The program to which the respective ship types belonged came to be designated by prefixing 1, 2, or 3 to the letters designating the hull type; for example, 2TL is the 10,000-ton tanker built according to the specifications of the Navy Technical Bureau's original program. The particulars on each of the standard type ships is given in Appendix 3.

The establishment of a limited number of standard types of ships resulted in most shipyards in the reduction of the variety of ships built in any one period of time and thereby introduced a degree of specialization within the function of merchant construction. The degree to which the various shipyards confined their merchant ship construction effort to a few or even to one type of ship corresponded closely to the degree of specialization, in the respective yards, in merchant ship construction as against the other lines of ship work. The higher order of specialization concerning the number of ship types built during the war was, like the other, carried much further in the new yards.

For purposes of measuring specialization by type of ship built, differentiation is made only between the basic hull types. Some of the cargo hull types, such as As and Es, were finished as tankers and at other times some tanker types such as TLs and TMs were finished as cargo ships. These variations and the different program designations are not counted as distinctive types. Ships built during the war, but before the final standardized program got under way, may be typed roughly according to a scale of 8 tonnage classes divided at 500, 1000, 2,000, 3,000, 5,000, 7,500 and 10,000 tons. Fishing vessels, tugs and miscellaneous vessels, such as dredges and power derricks, make 3 more general types, giving a total of 24 categories into which ships' hulls may be classified. Inasmuch as many of the nonstandard types were similar to and predecessors of various standardized types, nonstandard ships of the same tonnage class as standard ships built in the same yard are not counted as a separate type.

In terms of the foregoing classification of ships hulls, the degree of specialization by type during the war is indicated in the following schedule:

Different hull types built	1	2	3	4	5	6	7	8	9	Total
Number of major yards (Classes 1, 2, 3)		1	2		5	1	1	1	1	12
Number of large minor yards (Classes 4, 5)	5	4	6	4	3					22
Number of small minor yards (Class 6)	6	6	5	2						19
Total number of yards	11	11	13	6	8	1	1	1	1	53

The correlation and interrelationship of specialization in function, specialization in type of ship produced, and newness of the yard are shown on Chart 4, page 12, which lists separately for the new yards and the old yards the percent of total ship tonnage delivered by yards classed by the extent to which they specialized in merchant ship construction and by the number of merchant ship types produced.

Four of the new yards producing only one type of ship were designed specifically for the production of an 880 gross tons standard ship designated as type E by the Japanese. All 4 yards were built in 1943 and each had delivered well over 100 ships by the end of the war. The 568 E ships produced in these 4 yards were 96 percent of the total production of ships of that type in Japan.

One rebuilt yard, Koyogijima of Kawamimami, accounted for 85 percent of the tonnage delivered by new yards producing 2 types during the war. Aside from the 8 non-standard 1,900-ton ships delivered by that yard early in the war, production was concentrated in the 6,000-ton class. After October 1943, all deliveries were of the 6,800 tons standard hull designated as type A. The 51 ships of the tonnage class delivered by this yard were 30 percent of the total production of that type in Japan.

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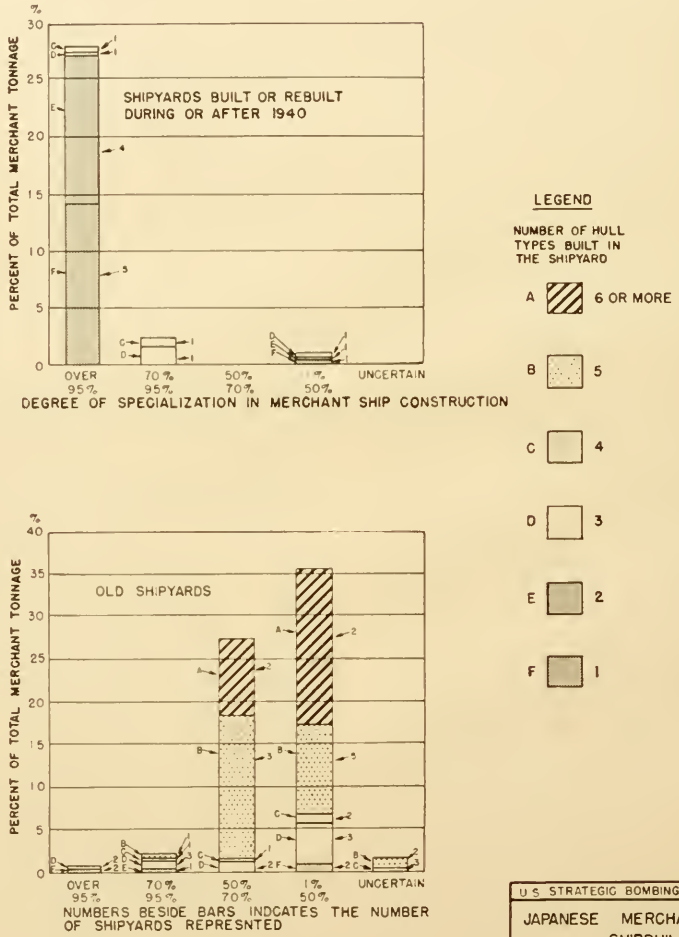
DISTRIBUTION OF MERCHANT TONNAGE DELIVERED DURING THE WAR AMONG SHIPYARDS ACCORDING TO THE AGE AND DEGREE OF SPECIALIZATION IN THE YARD



U.S. STRATEGIC BOMBING SURVEY

JAPANESE MERCHANT SHIPBUILDING

CHART 4

The other large producers of merchant ships were old yards, simultaneously and heavily engaged in naval ship construction or ship repair and conversion work. Furthermore, their merchant ship building efforts were spread among five or more types of ships.

Technological Methods

The older shipyards of Japan built ships up from the keel on conventional end-launching building ways. Material was designed and fabricated in the usual assortment of plate shops, boiler shops, forge shops, machine shops, carpenter shops, pattern shops, etc. The yards that built their own ships engines were equipped with larger machine shops for the purpose.

These older yards were almost invariably congested and not well organized for a smooth flow of production. Their growth had been piecemeal, hence, did not conform well to any systematic layout plan. The old yards, furthermore, were almost invariably seriously overcrowded. Good sites for shipyards, expanses of low flat land alongside deep water, are comparatively limited in Japan because of the preponderance of rugged terrain along the coasts. The few places in Japan where considerable flat area is adjacent to protected deep water are occupied by cities. Such expansion as was managed in the older yards, therefore, entailed either the creation of filled land in shallow sections of water front or the encroachment on adjacent industrial properties for the yards on the large city water fronts, whereas for other yards excavation and tunneling of hills was involved. These means of expanding acreage for the yards were too expensive for peacetime purposes and too slow for wartime demands, hence most of the expansion undertaken in the old yards either increased the congestion in the old area or was still incomplete when the war ended.

Taken together, the congestion and the lack of specialization in the old yards made a systematic, smooth, controlled flow of work practically impossible. Hence, there was an inevitable preoccupation with this or that particular ship from time to time resulting in erratic variations, in many of the yards, in the building time required for different ships of the same or similar type.

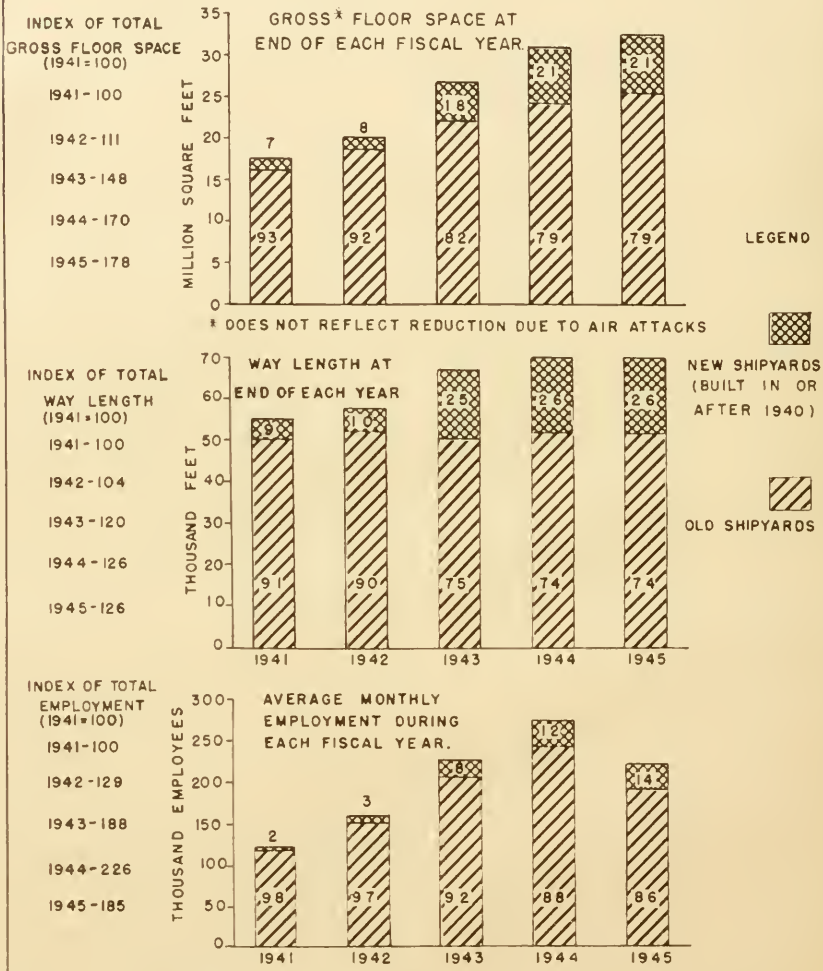
The shipyards which had been built or rebuilt during or immediately before the war not only held the advantage of a high degree of specialization but also went far in avoiding the handicap of congestion. The four E-ship builders were designed as complete operating units before ground was broken and sites were selected that provided adequate ground space from the outset. The Koyogijima yard had the usual rugged terrain to contend with, but inasmuch as its reconstruction was started in 1940, time was available for considerable hill cutting and tunneling for its new facilities.

Among the new yards, the full advantages of planned layout and high specialization were most nearly realized by the yards employing modern ship-building procedures. Instead of the conventional piecemeal construction on single-position building ways, four of these new yards built their ships in multiposition stages either on rails or in drydocks and employed block preassembly at least to some degree. The advantage of the use of these techniques is indicated by the fact that the one of the four large scale producers of the 880-ton E-type ship which employed the conventional single-position techniques averaged 90 days each in building 115 ships, while the other 3 yards took an average of 34, 37, and 67 days to build 163, 154 and 136 ships, respectively.

The Koyogijima yard was the only yard building ships over 1,000 tons which made any fundamental departure from the traditional shipbuilding procedures. The principal feature of its reconstruction beginning in 1940 was the building of a large graving dock capable of handling two A-type ships abreast in three different stages of construction, each stage being in separate compartments. In the use of block preassembly, welding and other modern techniques the Koyagijima yard did not differ materially from the other major yards. The Kanagawa yard at Hitachi was designed to include a similar building dock for A-type ships but was started too late (1944) to be brought into volume production before the end of the war. The failure to build or rebuild other large ship producing yards before the war or in its early stages reflects a lack of technological imagination on the part of Japanese shipbuilders and policy makers. This may have been partially due to the preoccupation of most of the leading shipbuilders with the heavy naval construction program.

Welding was not highly developed in Japanese shipbuilding. Even in the few yards pro-

EXPANSION OF COMMERCIAL SHIPYARDS DURING THE WAR



NUMBERS IN BARS REFLECT PERCENTAGE DISTRIBUTION OF TOTAL BETWEEN OLD AND NEW SHIPYARDS.

U.S. STRATEGIC BOMBING SURVEY

JAPANESE MERCHANT SHIPBUILDING CHART 5

ducing the E-type ships the use of welding varied from 50 to 70 percent of all seams and connections. For the larger type ships in the large yards the percentage of welding ranged from 10 to 45 percent, was generally about 30 percent. Only the simplest types of welding were attempted. Large sections were always riveted to avoid locked-in stresses.

Expansion and Changes During the War

The Japanese delayed any important expansion of their commercial shipyards for more than a year after the outbreak of the war. The industry increased by about one-third in 1943, however, and substantial new construction continued to the end of the war.

The extent to which the wartime expansion was accomplished by the construction of new yards as against the expansion of old yards is best indicated by the distribution between them of the increase in floor space and average employment. Of the new floor space built between 31 March 1942 and 15 August 1945, 39 percent was built in new yards started during or after 1940. The other 61 percent was built in the older yards. The difference between the average monthly employment in the fiscal year 1941 and that of the wartime portion of the fiscal year 1945 was divided 28 percent in the new yards and 72 percent in the old yards. Roughly one-third of the increase in the dedication of the whole economy to commercial shipyards took the form of altogether new yards. The balance went into the enlargement and strengthening of the old yards.

The trends of total floor space under cover, of total length of shipbuilding ways and of average employment from time to time give together a fair indication of the trend of production capacity. Chart 5, page 14, shows the totals of the first two of these items as of the end of each fiscal year during the war and shows average monthly employment for each fiscal year. The chart shows the distribution in each instance between the old yards and the new yards which include all yards and construction of which was commenced during 1940 or thereafter. There were 15 such yards distributed 5 each in Classes 4, 5, and 6.

The floor space represented on Chart 5 is the total floor space constructed by the Japanese less that removed by them. It does not reflect the amount of floor space damaged or destroyed by allied air attacks. Exact data are not available, but a considerable portion of the expansion in floor space, especially in the older larger yards, was in the form of dormitories and mess halls for the large number of conscripted laborers brought in to the shipyards during the war. In the older yards most of the increase in plant buildings were new machine shops and engine making facilities.

Centralization of Control

Before the war there was little direct government control of shipbuilding. Subsidization of ship construction and of the operating ship lines which ordered the new ships gave the government only an indirect voice in the shipbuilding program. When war broke out the Ministry of Transport and Communications, which had jurisdiction of shipbuilding inspection and repair, established over-all shipbuilding plans covering the scheduled production for all shipyards. In the period between the beginning of the war and the end of March, four different schedules indicating what each shipyard was expected to build were issued from time to time. The fourth one, dated 25 March 1942, was the first to be issued after the adoption of the first standardized ship program and was, therefore, the first plan to include standardized ships.

To facilitate control of matters related to shipbuilding, the Transport and Communications Ministry established the Shipbuilding and Repair Control Association (Toseikai) in January of 1942. It included all important shipbuilders, engine-makers, auxiliary and fittings makers, and associations of wooden shipbuilding yards and of small components manufacturers. The association administered the scheduling of ship repairs, and for new construction acted as a clearing house between the government and the industry in maintaining schedules, fixing prices, standardizing specifications for ships and components and procuring components and labor.

Contracts with the shipyards for new ships were made through the wholly-owned government Industrial Equipment Corporation which in turn sold the ships to the ship operators to whom they had been allocated by the government. The sale of the ships was at the scheduled standard cost established for all standard ship types. Shipyards were indemnified by the

Equipment Corporation for allowable costs incurred in excess of the standard.

By summer of 1942 it became apparent that progress in merchant ship construction was inadequate. For several years the navy had engaged a progressively greater proportion of the shipbuilding capacity for its own building program. Both the army and navy took increasingly larger shares of the available raw materials and labor force leaving progressively less for merchant ship construction. And the program established by the Communications Ministry involved too many types and was too loosely administered to accomplish even the best results possible under the circumstances. In July 1942, responsibility for the construction of steel ships of more than 50 meters in length was therefore transferred to the navy department, where a merchant ship section was created under the Navy Technical Bureau (Konsei Hombu). The authority and responsibility for allocating raw materials among shipyards was also vested in the Bureau. Later, responsibility for all steel ship construction, repair and inspection was transferred to the Navy. The Navy Ministry was further directed to assist the Communications Ministry in the procurement of engines for the wooden ships, the construction of which remained under the jurisdiction of the Communications Ministry throughout the war.

Wooden Ship Construction

In marked contrast to the shipyards building steel ships, there were literally hundreds of small widely dispersed shipyards participating in the wooden ship construction program.

The largest wooden shipyards in all Japan had 32, 29, and 25 building ways, respectively. Together these amount to less than 4 percent of all the wooden shipbuilding ways in Japan. The absence of concentration is further indicated by the following tabulation:

	Number of yards	Percent of total	Number of Building ways	Percent of total
Yards with 10 or more ways	43	8	600	26
Yards with 4 to 9 ways	236	43	1,350	57
Yards with 1 to 3 ways	269	49	40	17
Total	548	100	2,350	100

The bulk of wooden ship construction was conducted in yards with about a half dozen building ways.

The geographical distribution was similarly widespread. Several yards were located in large cities, but most were scattered among smaller towns and villages In fact there was hardly a seacoast town in Japan that didn't have one or more of these small yards. The geographical distribution of the wooden ship building industry is indicated by the following tabulation:

Area	No. of yards	Percent of total	No. of ways	Percent of total	Production (1,000 tons)	Percent of total
Hokkaido and North Honshu	77	14	447	19	82	20
Central Honshu	130	24	524	22	79	19
Western Honshu	188	34	709	30	126	31
Shikoku and Kyushu	153	28	670	29	124	30
Total	548	100	2,350	100	411	100

Although the industry is fairly evenly distributed throughout Japan, the most important areas are those surrounding the Inland Sea. Development in the northern area came later in the war than in other areas, but included 40 percent of all the yards in Japan with 10 or more building ways.

The small size of the establishments practically compelled the wooden shipbuilding yards to specialize in new ship construction, though a certain amount of servicing and repair was done in some of the older more fully equipped yards. Very few yards made their own engines. The semi-Diesel engines used in wooden ships also were produced by numerous small establishments of which only 12 built more than 5,000 horsepower annually. This was about 2 percent of the total average annual production.

A degree of standardization was realized in the wooden ship program. The initial schedule established in September 1942 included 2 sizes of full-powered wooden ships with steel strength numbers, 5 sizes of cargo vessels varying from 70 to 250 tons which could be used with auxiliary power or with sail only, adaptation of 3 of these sizes as oil tankers, and 2 sizes of wooden tugs. Altogether this represented nine distinct hull types. Late in 1944 the schedule of wooden ships was altered to include 4 small auxiliary-powered fishing vessel types varying from 19 to 55 tons while 2 of the 5 regular cargo sizes were eliminated. In addition to these standard type vessels, numerous barges and lighters varying from 50 to 150 tons were built by these yards thoughout the war.

The small size of most of the wooden ship-

building yards resulted automatically in a high degree of specialization as to type of ship produced in a given yard. The techniques were entirely traditional and were simple enough to be within the skill of the average Japanese carpenter, which is generally good. As a large proportion of the yards and an even larger proportion of the workmen were new in ship work, systematic instruction in the construction of the standard types was undertaken by the Ministry of Communication and Transportation which had the over-all administrative responsibility for wooden ship construction through the war.

IV. DEMANDS ON THE SHIPBUILDING INDUSTRY

Shipping Needs

The wartime demand on shipyards for new merchant ship tonnage depends on the prospect that the tonnage afloat can, in the forseeable future, meet the demand for overseas transportation. The prospective adequacy depends on the existing amount of tonnage afloat, prospective losses, and the average ship performance that can be expected under forseeable operating conditions taking into account the capabilities and condition of the ships, the necessity for convoying, circuitous routing, and similar matters. The prospective demand for overseas transportation is twofold. To the extent that military operations are overseas, initial movements and supply maintenance must be provided by shipping. To the extent that the civilian economy in each separate land mass is not self-sufficient, either for its own maintenance or for the required war production, raw materials and processed goods must be shipped. The demand for shipping on the part of both military and civilian requirements depends not only on the tonnage of such traffic but also the distances involved.

The heavy demand for shipping when the Japanese were prosecuting aggressive warfare in the Solomons and the Central Pacific is brought out in the report of the Military Analysis Section of the Survey. The utter lack of self-sufficiency of the home economy in Japan proper in such vital respects as coal, iron, oil, bauxite, and food is brought out in the report of the Transportation Section of the Survey. As Japan moved from a peacetime to a wartime economy her relative lack of self-sufficiency in the home islands increased because the shift increased the relative importance of the demand for precisely the raw materials which she lacked at home.

The shift toward a wartime economy began with the China incident in 1937 and accelerated steadily up to and after the outbreak of the war. The shift to a total war economy was not fully realized until 1943. Hence on this score alone, there was an ever increasing demand for shipping from 1937 through 1943.

The preparation of an estimate of the ship tonnage required to sustain the Greater East Asia Co-prosperity economy at various assumed levels and under various assumed war circumstances would require quantitative estimates of shipping needs which are beyond the scope of this paper. It may be said, however, that in view of the great increase in the demands for shipping with the advent of war, the adequacy of the Japanese merchant marine on Pearl Harbor Day (including subsequent seizures and captures) to meet the demand for shipping is doubtful. It has already been pointed out that conversion to a total war economy, entailed increased demands for shipping, continued into 1943. Not until Japan gained the extremely questionable advantage of shortened trip distances by being cut off from the southern regions was there any appreciable reduction in the economic demand for shipping. Not until she ceased to attempt the defense of outlying islands was there an appreciable decrease in the military demand.

Shipping Available

Practically every one of the dynamic factors affecting the availability of ton-mile overseas carrying capacity except new construction operated negatively for the Japanese throughout the course of the war. Sinkings took progressively higher percentages of her tonnage afloat; time-consuming defense practices such as traveling in convoy, circuitous routing, and traveling only at night became more and more essential; the condition of the ships deteriorated as a result of heavy usage and undermaintenance; and as the composition of the merchant marine changed with the slower, less seaworthy war-

time standard types partially replacing prewar ships, the average capabilities of the existing tonnage declined.

Data are not at hand to afford estimates of the ton-mile overseas cargo carrying capacity of the Japanese merchant marine from time to time during the war. However, the analysis in Table 3, page 18, of a principal factor in that capacity—the over-all operable tonnage available from time to time—shows the relative importance of new ship construction in the effort of the Japanese to maintain a merchant marine in operation.

TABLE 3.—*Changes by fiscal years during the war in the total of operable tonnage of Japanese steel merchant shipping over 500 gross tons*

[1,000 gross tons]

Time	Tonnage status			Tonnage changes				
	Afloat	Laid up	Operable	Captured, salvaged	Built new	Sunk	Net change	Built—sunk, percent
7 Dec. 1941	5,996	700	5,296					
Fiscal year 1941 (wartime portion)				331	68	246	−153	28
31 Mar. 1942	6,150	775	5,375					
Fiscal year 1942				377	362	1,156	−417	31
31 Mar. 1943	5,733	900	4,833					
Fiscal year 1943				90	1,095	2,506	−1,381	43
31 Mar. 1944	1,352	825	3,527					
Fiscal year 1944				25	1,590	3,502	−1,887	45
31 Mar. 1945	2,465	806	1,659					
Fiscal year 1945 (wartime portion)					179	830	−651	22
15 Aug. 1945	1,814	1,137	677					
Duration of war				823	3,294	8,300	−4,183	40

[1] Estimated for ships assigned to Army and Navy through 31 Mar. 1944 as reported; includes operable tonnage cut off in the southern regions thereafter

New construction increased steadily from about one-fourth the rate of sinkings in the corresponding period at the war's outset to almost one-half in 1944 when the maximum building effort was being exerted, then fell back again in 1945 to about one-fourth. Even if production could have continued to increase faster than sinkings by the same rate of gain shown up to 1944, the balance of the merchant marine afloat would have been wiped out long before production could catch up with sinking. In fact the gap between production and sinking, even when narrowest, was so large that the failure to maintain tonnage afloat lies principally with the failure of the Jap navy and air forces to prevent sinkings. Even though merchant ship production could have been somewhat greater, it was not within the production potential of Japan to produce at the rate required to offset the rate of sinkings.

Every factor affecting the demand for new ships—especially the demand for shipping space, the rate of loss of existing ships, and the reduction in operating efficiency of existing ships—pointed from the very beginning of the war to the necessity for all-out merchant ship construction to keep Japan in the war. The Japanese either did not fully understand the urgency of this need until the beginning of 1943 or were unable to rise to the occasion until then. The Japanese Navy must be credited with a large share of the responsibility for this state of affairs. Not only did it fail to protect merchant shipping adequately, but its overconfidence in its ability to protect shipping no doubt justified in its own mind its policy of preempting through 1942 a very large share of shipbuilding capacity for naval construction.

Demand for Special Types

With the outbreak of war, the Japanese were confronted with a great increase in demand for petroleum transportation. The conduct of the war brought about a large increase in petroleum requirements at home which could only be met by transportation over long distances as from Singapore and the NEI to Japan. Hence, there existed a great demand for the creation of additional tanker tonnage.

More than 400,000 tons of cargo ships were converted into tankers during the fiscal years 1941 and 1942 and almost 1,000,000 tons of new tankers were built during the war, mostly in 1943 and 1944. In spite of the delay in the incidence of effective Allied attack on tankers, however, the Japanese were never able to provide enough petroleum transportation to meet the demands even as recognized by themselves. It was not until it was considered no longer a worthy risk to send tankers to the south that efforts to meet the demand for new tankers ceased. That decision was made in January 1945. The increases and decreases in tanker tonnage are summarized in the following tabulation which is expressed in 1,000 gross tons:

War period by fiscal years	1941	1942	1943	1944	1945	Duration
Captured and salvaged	37	32	6			75
Converted from cargo	119	118	19	66		322
Built new	1	55	375	555		986
Total gross increase	157	205	400	621		1,383
Converted to cargo				25	25	50
Sunk	9	30	389	865	77	1,370
Percent sunk of gross increase	6	15	97	139		101

Fortunately for the Japanese petroleum position, effective Allied attack on tankers was slow in developing in spite of the preference of all hands for tanker targets. Actually the Allied forces thought they were sinking tankers. Perhaps they were somewhat misled by the fact that all of the wartime standard ships, cargo as well as tanker, were of the stacks-aft design generally considered characteristic of tankers only.

As the volume of freight increased on the Japanese railroads the demand for railroad car ferry service increased, especially on the Hakodate-Aomori run connecting Hokkaido and Honshu. As this service was vital for the import of food and coal for Honshu, the demand on these facilities grew steadily throughout the war and made the construction of additional ferries urgent.

Even in peacetime the Japanese had always made considerable use of small vessels of less than 500 gross tons—both steel and wood. Such vessels were used extensively in the all-important coastwise trade, especially in the Inland Sea, and made up a substantial proportion of the large Japanese fishing fleet.

During the war new demands for these small craft materialized rapidly. A considerable part of the larger ship tonnage previously engaged in coastwise trade in Japan was diverted to overseas traffic. At first most of the traffic they had handled was transferred to the railroads. As the railroads approached the saturation point, the demand arose for large quantities of small vessels, particularly auxiliary powered wooden sailing ships traveling either separately or in tows. Many of the better prewar small vessels were themselves requisitioned by the armed forces for use in conducting the island warfare in the south and central Pacific. As the air attack on shipping became felt in home waters, the advantages of small vessels in being a more dispersed target and being less likely to explode mines increased the premium on the use of this type of shipping and increased the demand for their construction.

Certain special types of small vessels also were needed urgently. New tugs, both for use of the military and for handling the increased volumes of port activity throughout greater East Asia, were needed continuously. When food imports became seriously impaired in the latter phases of the war the premium on the construction of small fishing vessels rose accordingly.

Diversionary Demands for Naval Construction

Mention has already been made of the limitation of the construction of merchant ship tonnage in the early stages of the war imposed by the large amount of heavy naval ship construction done in the commercial yards through 1942. Keels were laid in the commercial yards for the battleship *Musashi*, six aircraft carriers, and three cruisers from time to time during the 4 years preceding the war. Two of the cruisers were delivered in 1940, two carriers and one cruiser were completed before the war in 1941, the battleship and two carriers were delivered in 1942, and two carriers in 1943. Three large carriers were started during the war, in October 1942, April and July 1943, respectively. The first was delivered in August 1944 and the other two never were completed. Three more carriers were on the schedule of the Nagasaki-Mitsubishi yard — the first of which was to be started in October 1943—but all three were canceled. The great bulk of the heavy naval ship construction program for the commercial yards was carried over from the years immediately preceding the outbreak of the war. Not until after July 1943, however, did the navy cease to order large ships from the commercial yards.

Three commercial yards were involved in the construction of these ships. The battleship and five carriers were built at the Nagasaki yard, four carriers at the Kobe-Kawasaki yard and the cruisers at the Yokohama-Mitsubishi yard. The existence of a substantial diversionary effect of this heavy naval ship construction is shown by the comparison of the merchant tonnage production of these three yards with the production of all other commercial yards in operation throughout the same period.

Fiscal year	1937	1941	1942	1943
Three naval shipbuilders:				
Merchant tonnage	187,276	54,775	88,106	248,854
Index (1937 = 100)	100	29	47	133
Other commercial yards:				
Merchant tonnage	255,106	182,842	272,833	717,854
Index (1937 = 100)	100	72	107	281

The wisdom of dedicating three of the largest commercial yards so completely to heavy naval ship construction must take into account the demand for such ships, which cannot be assessed here. The extent to which the capacity

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was diverted without the construction of compensating new merchant shipbuilding capacity does, however, manifest a preoccupation on the part of the navy with its own expansion program.

With the conclusion of most of the work on large fleet units in 1942 the dislacement tonnage of combatant naval ships delivered from the commercial yards receded from 149,000 to 81,000 tons in the fiscal year 1943. The principal items in the latter year were coast defense ships (22,000 tons), destroyers (19,000 tons) and submarines (17,000 tons). In 1944 the production of destroyers in the commercial yards declined somewhat, while submarine production increased. The great increase in the tonnage of combatant ships (148,000 tons total in 1944) came in the coast defense vessels; 82,000 tons of this class of ship were delivered from the commercial yards.

Of the 169 coast defense ships built by the Japanese during the war, 154 or 91 percent were built by the commercial yards. While 14 commercial yards participated in this program, 80 percent of the total produced in commercial yards came from major yards simultaneously building A-type cargo ships or TL-type tankers. The choice lay between building more merchant tonnage or sacrificing that and building more of these Kaibokan with the hope of keeping existing merchant tonnage afloat. No available evaluation of their effectiveness is sufficiently specific to permit an estimate of the tonnage of merchant shipping saved by these ships. As an antisubmarine weapon their speed (16.5 to 19 knots) was low and their durability had its limitation. During 1944 the Kaibokan construction schedule for several yards was curtailed or canceled and destroyers scheduled in their place.

Demand for Merchant Ship Repairs

As ship repairs require many of the same facilities and skills as new construction, the demands for those services as well as the demand for naval ship construction are largely competitive for available capacity. Unlike naval ship construction however, the demand for merchant ship repairs stems directly from the same need that constitutes the demand for new merchant construction, namely, the demand for overseas transportation.

The proper balance between new construction and ship repair is, in short run, one of the comparative cost of putting an existing ship that is laid up back into service as against building a new one in its place. In the long run, however, the optimum balance of effort shifts in the direction of greater effort on repair by virtue of the inclusion of routine maintenance to forestall breakdowns and maintain operating efficiency in addition to putting completely immobilized ships back into service. The fact that maintenance is a long run provision and can be postponed means that a merchant marine may borrow on its future by letting maintenance go over longer periods or indefinitely.

Data are not available to show what the prevailing conditions of the Japanese merchant marine, and hence the real need for repairs, were from time to time during the war. All Japanese sources, however, report that maintenance was consistently postponed throughout the war resulting in progressively increasing breakdowns and forced lay-ups as the war progressed. The economy of design and rapidity of construction of the wartime standard type ships resulted in a higher over-all rate of structural failures and engine breakdowns as these ships become more numerous. Battle damage could be expected to increase in proportion to the intensity of the over-all attack on shipping. When mines become a major antishipping weapon of the Allied attack a great increase in the repair requirements was inevitable.

The Japanese were compelled to do more ship repairing than they planned. The estimate of the Naval Technical Bureau of the tonnage that would be in for repair during 1943 was raised from 4,700,000 tons to 7,200,000 tons for the shipyards in Japan. Estimates for 1943 and 1944 compare with the actual tonnage reported by the shipyards as follows:

	Fiscal year	
	1943	1944
	Tons	*Tons*
Estimated by navy	7,200,000	6,000,000
Actually repaired	8,595,000	9,576,000

About one-fourth of the Navy's estimate for 1943 was provision for anticipated battle damage, whereas in actual experience only about one-fifth of the tonnage of ships under civilian control which came in for repairs were in for battle damage. The indication is that the urgent demand for operational repairs even during the middle period of the war was much higher than was originally anticipated.

The progressive increase in the percentage of tonnage afloat that was laid up for repair from time to time indicates the over-all effect of the policy of deferring maintenance in the early stages of the war, the decline in the average quality of the merchant marine, and, particularly at the end, the effect of battle damage and general demoralization. The percentage relationship of tonnage laid up to tonnage afloat on the dates shown in Table 3, page 18 are listed below. The shipping cut off in the south amounting to 184,000 tons on both 1945 dates is deducted from both the tonnage afloat and tonnage laid up before the relationships are computed for those dates.

	Percent
7 December 1941	12
31 March 1942	13
31 March 1943	16
31 March 1944	19
31 March 1945	27
15 August 1945	58

The tendency on the part of the Japanese to underemphasize provision for ship repairs led to the scheduling of construction of new ships in several important yards which had previously specialized in ship repair. These included the Innoshima-Hitachi yard (Class 3), Hakodate and Mukaishima-Hitachi yards (Class 4), and Asano-Japan Steel Tube and Kasado yards (Class 5). In most instances new facilities, including building ways, had to be built and the size ships built and volume of production both were comparatively small. In ship repair work done in 1943 these yards actually handled 400,000 tons less than the 2,000,000 tons scheduled for them by the Navy plans. In the meantime, 5 of the 6 Class 1 and 2 yards were called upon to repair 1,200,000 tons in excess of the 1,800,000 tons scheduled for them by the navy. It follows that the Japanese frittered away some of their specialized ship repair capacity in the interest of picking up a few extra tons of new construction and, being caught in a pinch, had to call upon their best yards to divert effort from the big time construction program to do a lot of extra ship repair work.

V. PLANS AND PRODUCTION

Over-all Volume and Relationship of Planned and Actual Deliveries

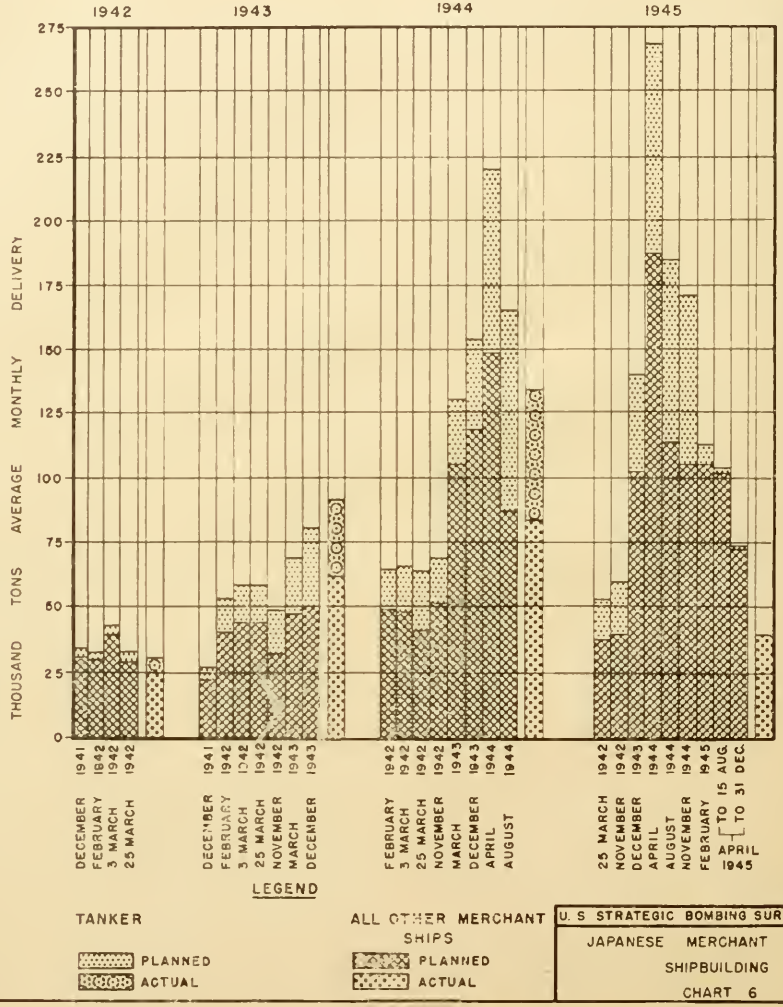
The war is divided into three periods as far as the volume and relationship of planned and actual deliveries of new merchant tonnage are concerned. From the beginning of the war until December 1943 the plans for the future were for consistently lower rates of production than were found necessary and feasible actually to realize when the time came. From December 1943 to February 1945, plans for the future consistently exceeded the maximum annual rate of construction ever achieved by the industry. During 1945, plans were sharply and progressively curtailed while production fell off even more dramatically to levels reminiscent of prewar production.

The comparison of the average monthly rate of delivery for each fiscal year scheduled in the various plans with the average monthly rate actually achieved in the respective years is shown in Chart 6, page 22. Details of each of the plans are given in Appendix 4. The over-all totals on the chart are broken down between tanker and all other merchant ships to permit comparison of planned and actual production in the respective categories. The latter category includes comparatively small amounts of passenger ships, ferries, tugs and other special types but consists very largely of dry cargo ships including a substantial tonnage of ore carriers.

The first failure of the Japanese consisted of the delayed recognition of the ultimate volume of demand for ship construction. An indication of the delay is shown by a comparison of actual production in 1942, the plans for 1942 and 1943 and the plans for 1944 and 1945 which were made during the first 2 years, on the one hand, with actual production in 1943 and 1944 and later plans for 1944 and 1945 on the other hand.

The second failure of the Japanese lay in the inability of the industry to meet the schedules established in the light of the urgent needs. An indication of the inability is shown by a comparison of the plans for 1944 and 1945 made in the latter part of 1943 and during 1944, on the one hand, with actual production in 1944 on the other hand. All of these plans, including that of April 1944, presumably were within the capacity of the industrial plant for which the

PLANNED AND ACTUAL MONTHLY AVERAGE RATE OF DELIVERIES OF TANKERS AND OTHER MERCHANT SHIPS BY FISCAL YEARS



plans were made. But for reasons which will be examined later, production even at its peak was considerably below the scheduled volume.

The third failure of the Japanese was the precipitous decline in production in 1945, which came with the general decline and demoralization of all Japanese industry. That the failure was much worse than had been anticipated is shown by a comparison of the production plan of April 1945 with actual production in that year.

Representing as it does the effort of the Japanese planners to adjust merchant ship production schedules to the decelerating pace of Japanese industry, the plan of April 1945 is of peculiar interest. The plan covered only the first 9 months of fiscal 1945. All previous plans had covered at least a year in advance; some had covered four. Also unlike the others, this plan set up two different goals. A "primary" goal of 567,000 tons was scheduled for approximate completion in 6 months. The completion of this program was considered absolutely essential. A "secondary" goal of 666,000 tons represented the continuation of the schedules through most of the first 9 months of the fiscal year. This objective was to be achieved if materials were available. The comparison of the actual average monthly rate of production between 1 April and 15 August 1945 with the corresponding rate scheduled in the April plan shows deliveries for the period to have been less than half the amount scheduled.

Tanker deliveries appear to have done better at meeting schedules than other types of merchant ships. The apparent superiority reflects the higher priority assigned to tankers from December 1942 to January 1945. The priority was implemented by the assignment of tanker construction to what were considered the most reliable shipyards and when production began to lag, previously scheduled cargo ship production was rescheduled for completion as tankers.

The effect of the decision in January 1945 to discontinue tanker production because of the impossibility of continuing traffic with the southern region is shown by the plans for 1945 announced in February and April 1945 and completely confirmed by the fact that no tanker tonnage at all was delivered in 1945.

Planned and Actual Deliveries by Standard Ship Type

Comparison of the relative importance of the different ship types in the various plans and in the actual production for the fiscal year 1944 summarizes the evolution of the importance of the various types and, to a limited extent, reflects their relative performance in meeting schedules. Plans for 1944 made in the early years reflect the relative emphasis on the various types then under construction except that nonstandard ships, having been completed, have disappeared from the schedules for 1944. Since the wartime production peak was passed during 1944, the comparison of actual production to peak level schedules point out the ship types in which hopes and disappointments were greatest. The annual tonnage planned for each standard type ship from time to time for the fiscal year 1944 and the tonnage of each type actually delivered in that year are shown in Chart 7, page 24.

The evolution shown on Chart 7 involves three major changes in planning. The contrast between the 1942 and 1943 plans represents the shift from the first to the second programs of standard ship design. Cargo types B, C and F, the ore carrier type K and tanker type TS virtually disappear. These reductions are offset by a great expansion in type E, the initiation of type TE and important increases in types D and TL. The most dramatic increase occured in type A which accounted for almost the entire amount of the over-all increase inspired by the realization that rapid ship construction was imperative.

The changes in the plans from March 1943 through April 1944 reveal that during the period in which production was expanding the hoped for continued increases were pinned primarily on types A, TL, and E and in that order. In April of 1944, the Japanese were calling on their new E-type producers and the large shipyards making As and TLs to produce at unprecedented production rates possible only with all yards, including the two new A-type producers Hiroshima - Mitsubishi and Kanagawa-Hitachi, operating at their maximum with uninterrupted flow of raw materials, especially steel.

The plan of August 1944 represents an admission of the failure of the ambitious program scheduled in the previous plan. All types are reduced somewhat, but 61 percent of the cutback is in the A-type tonnage. The continued urgency of the need felt for tankers is mani-

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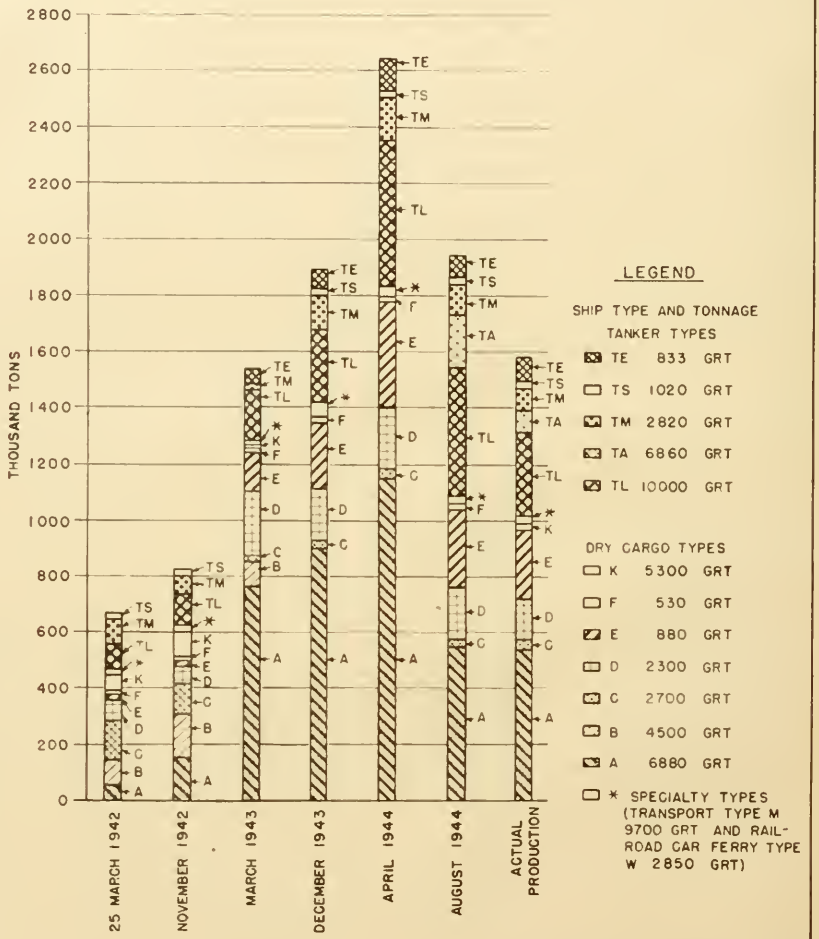
PLANNED AND ACTUAL TOTAL ANNUAL PRODUCTION BY STANDARD SHIP TYPES FOR THE FISCAL YEAR 1944



U.S. STRATEGIC BOMBING SURVEY
JAPANESE MERCHANT SHIPBUILDING
CHART 7

fested by the fact that in spite of the large cut-back in A-type hulls, 26 percent of the A-type ships scheduled in August were to be finished as tankers. Similarly, in spite of an 18 percent reduction in all type E's, the number to be finished as tanker-type TE is increased.

The decision in January 1945 to cancel the tanker construction program resulted in a rapidly declining rate of tanker delivery in the last quarter of the fiscal year. Hence, a comparison among types of the degrees to which they achieved scheduled production must omit that period. The percentage by which three-fourths of the annual production scheduled in the August plan was met at the end of the third quarter of the fiscal year 1944 (31 Dec. 1944) is shown in the following tabulation for ship types involving more than 20,000 tons actual production in that period.

Cargo types:		Tanker types:	
	Percent		*Percent*
A	93	TL	67
D	82	TA	58
E	92	TM	91
		TE	99

As among the cargo types, the fact that the poorest showing is made by type D is undoubtedly a reflection of the fact that this type was produced in small numbers by a substantial number of the larger minor yards. Fifteen different yards built type D ships, no one of which delivered more than 15 ships of this type during the entire war.

The Matsunoura-Harima yard, which built all of the type TE ships, not only did better than the 3 type E cargo ship builders in point of keeping up to schedule, but also produced 116 ships in fiscal 1944, while the other yards were producing 111, 82, and 71 ships, respectively. The construction of E-type tankers had been assigned to the best yard. Similarly the construction of type TM, approximately the same size ship as cargo type D, had been assigned almost exclusively to major yards — hence the superior performance.

The failure of type TL production to exceed two-thirds the volume scheduled in August, while type A cargo came within 93 percent of schedule, reflects the desperate tanker position the Japanese found themselves during this period. That they felt the position to be desperate is confirmed by the decision in the August plan to order a number of the scheduled A-type ships completed as tankers. Two factors contribute to the apparent contrast in performance on TLs and A cargo ships.

The large tankers were assigned to the four most heavily equipped commercial yards in Japan—Nagasaki and Yokohama yards of Mitsubishi, Kobe - Kawasaki and Aioi - Harima. These yards were at the same time heavily engaged in the construction of naval ships and other types of merchant ships. The 3 major yards which built 72 percent of the A-type ships during the war, Koyagijima-Kawaminami, Tamano-Mitsui, and Kobe-Mitsubishi, concentrated much more exclusively on this one type ship and hence were better able to meet their schedules.

The other factor contributing to the contrast makes the difference in performance seem more apparent than real. Because of the greater intensity in the demand for tankers throughout this period, the scheduled production of large tankers was raised much more readily and was lowered much more reluctantly than the schedules for the large cargo ships. This is shown in the following relationships of tonnages scheduled in the various plans for types TL and A (cargo only) respectively:

Plans compared	April 1944, December 1943	August 1944, April 1944	August 1944, December 1943
	Percent	*Percent*	*Percent*
Type A cargo	128	48	62
Type TL tanker	198	90	178

In other words, while plans for A ships went up one-fourth between December 1943 and April 1944, plans for large tankers were doubled, and while plans for large cargo ships were cut in half between April and August 1944, plans for TLs were reduced only 10 percent. The net over-all changes between December 1943 and August 1944 were a reduction by more than one-third for the type A cargo ships and an increase of more than three-fourths for the type TL tankers.

The rather dismal failure of the type TA tanker to meet its scheduled production may be attributed to the fact that it was a makeshift alteration program just getting under way. Only two of the five yards called on for this adaption were able to make deliveries of it.

Planned and Actual Deliveries Under the Wooden Shipbuilding Program

Throughout the war, wooden ship construction fell much farther behind its planned rate

of construction than did steel ship production. Plans for the wooden ship program were prepared 1 year at a time by the Communications Ministry. The first plan, announced in September 1942 for the remaining 7 months of the fiscal year, called for a substantial rate of production, but the amount actually produced was nominal. The planned rate of production was stepped-up considerably for 1942, but production was still very slow in getting underway. In fact, it was not until the last month of the fiscal year 1943 that the rate planned for 1942 was attained.

By 1944 the need for shipping of any and all description had become so urgent that the rate of planned production of wooden ships was again increased and measures taken to step up the actual production rate. As the year advanced, however, the actual production rate lagged, so an altered schedule was substituted reducing the production rate by about one-fourth. Actual production for the year amounted to about 60 percent of the altered schedule.

By April 1945 the need for small wooden vessels was, if possible, even more urgent. Hence the original plan for 1945 called for some increase, especially in nonpowered craft, over the altered rate for 1944. As in the previous year, the original program had to be revised downward, this time by one-half. Actual production was falling off even faster so that the over-all performance both in absolute tonnage and in relationship with the altered schedules was lower in 1945 than in 1944.

The planned and actual rates of production for each year shown in Table 4, page 26, are given separately for the two classes of wooden vessels and collectively for all such vessels as a whole. The powered ships include all wooden ships, whether cargo, tanker or fishing vessel equipped with some degree of power. Nonpowered craft include sailing ships, barges, lighters and special purpose craft without engines. The percent of scheduled production actually produced, shown in the table, gives a measure of the difficulty encountered in this production program.

TABLE 4.—*Average monthly tonnage of planned and actual production of powered and nonpowered wooden vessels by fiscal years during the war*

Period (fiscal year) plan	1942 (7 mos.)	1943	1944		1945 (5 mos.)	
	Original	Original	Original	Altered	Original	Altered
Powered ships:						
Planned	11,405	28,333	37,825	26,083	15,511	8,387
Actual	14	6,672	17,598		7,336	
Percent	0.1	24	47	67	47	87
Nonpowered craft:						
Planned	3,946	13,333	11,000	10,000	23,333	10,958
Actual	204	958	4,107		3,360	
Percent	5	7	40	41	14	31
All wooden vessels:						
Planned	15,369	41,666	48,825	36,083	38,844	19,345
Actual	218	7,630	22,005		10,696	
Percent	1	18	45	61	28	55

Two factors contribute to the consistent superiority, indicated by the table, in the performance of powered ship construction over that of nonpowered craft.

A higher priority was assigned the powered-ship production program through 1944 because of the greater urgency of the need for that product. Because of the greater urgency and because powered ships were larger and more difficult to build, their construction was assigned to the better yards, priorities on material and labor were more generously given, and the progress of the program more closely supervised.

The second factor contributing to the apparent difference in performance on powered vs. nonpowered vessels was the greater tendency to maintain and even to increase schedules on nonpowered craft in 1944 and 1945 despite the poorer showing that had been made. This was particularly true of the rate scheduled in the original plan for 1945, which was more than double the original 1944 rate.

The stepped-up scheduling of the nonpowered craft in 1945 did have some effect on production as shown by the fact that the production rate in 1945 dropped only to 76 percent of the 1944 rate, while the corresponding production of powered ships dropped to 42 percent. Nevertheless the basic advantages previously assigned to powered-ship production carried over into 1945 with the result that actual production in that classification amounted to more than twice the nonpowered wooden vessel production despite the fact that less (from two-thirds to three-fourths) was scheduled.

The bulk of the increase of scheduled nonpowered production in 1945 was in the provision for 225,000 tons of sea-going lighters to be built during the year as a part of the program to increase the use of barge tows for the Aomori-Hakodate run and in the Inland Sea. Practically the entire cut-back in the scheduled tonnage of nonpowered craft prescribed in the altered plan for 1945 was in the sea-going lighter category. Because of the extensive loss of harbor lighters in the incendiary air attacks the scheduled rate of construction of harbor lighters was practically unchanged in the altered program for 1945.

Of the 328,000 tons of powered wooden ships built under the entire wartime program, 304,000 tons were of the various standard cargo ship classes. About one-third was of the 250-ton type, another third in the 100-ton type, one-fifth in the 150-ton type, and the remainder in one or another of the 4 other types. The 23,000 tons of wooden tankers were about equally divided among the 250-, 150-, and 100-ton types. This distribution for both cargo and tanker production prevailed generally throughout 1943, 1944, and 1945. The 645 tons of powered fishing vessels built entirely in late 1944 and 1945 were about equally divided between the 55-ton and 19-ton types. Of all the kinds of powered ships, the construction of fishing vessels lagged behind schedule the most.

Monthly Economic Input in Merchant Ship Construction

The response of the shipbuilding industry to the demands for new construction is reflected immediately in the changes from month to month in the yen value input expressed in 1945 prices classified according to the major categories of ship types. Month to month input immediately reflects changes in the scales of effort both over-all and within the classifications and avoids the construction period time lag contained in an analysis based only on ship delivery. The use of yen value expressed in terms of a single price level reflects directly the share of economic effort dedicated to each class of ship and to shipbuilding as a whole. For comparison among ship classes, this reflection is accomplished by the fact that the yen values used amount to weights accounting for the differences in the economic requirements for producing a gross ton of each of the various kinds of ships. For comparison with other lines of war effort, yen value as of a given price level provides the only satisfactory common denominator of the volume of production.

The computation of monthly economic input is derived from the gross ton production of new ships. The gross tonnage completed of each ship produced or under construction at the end of the war was spread equally among the months during which the ship was under construction, including the months of keel laying and delivery. The tonnages assigned in this manner to each month, April 1941 through August 1945, were totaled by standard ship type or comparable class of nonstandard ships and the total unit cost per ton, 1945 prices, for each such class applied. The total of the resulting input values for the ship types constituting each general ship classification and for all ships as a whole represents the monthly economic input of merchant ship construction.

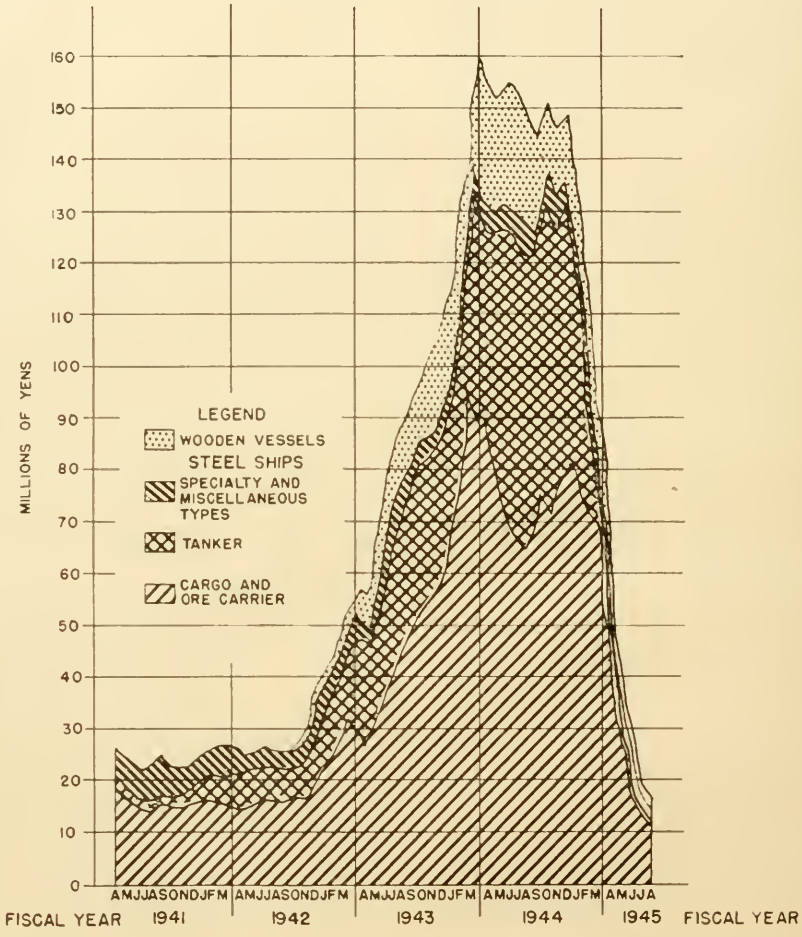
The monthly economic input devoted to the construction of cargo and ore carrier ships, tankers, specialty and miscellaneous types, and wooden ships, as well as for the over-all total for new ship construction, is shown on Chart 8, page 28. Supporting data on yen value of input in the construction of various classes of merchant ships and on ship repair and conversion together with index numbers based thereon are given in Appendix 5.

The scale of effort on new ship construction during the first 11 months of the war did not materially exceed that of the preceeding 8 months. The significant increase in effort on tankers was largely offset by the decrease in passenger ship construction included in the specialty types on the chart.

Not until November of 1942 did the expansion in the shipbuilding effort begin in earnest. In the 15 months from October 1942 through January 1944 the over-all scale of effort increased to six times the original. The rate of increase was so great, particularly in tanker and wooden ship construction, that the peak-recession production pattern at the end of the fiscal year 1942, which is characteristic of most lines of Japanese government-controlled production, was almost entirely submerged.

The 162 million yen all-time peak in ship construction effort, which occured in January 1944, is essentially a reflection of the all-time peak effort in cargo ship construction which

MONTHLY YEN VALUE INPUT FOR PRINCIPAL CLASS
OF MERCHANT SHIP CONSTRUCTION APRIL, 1941 - AUGUST, 1945
EXPRESSED IN 1945 PRICES



U.S. STRATEGIC BOMBING SURVEY

JAPANESE MERCHANT SHIPBUILDING

CHART 8

reflected, in turn, the characteristic year-end surge in effort to meet quotas and earn bonuses established for the fiscal year. As the fiscal year ended, the effort on tankers continued to increase at a pace sufficient in April to offset the usual recession after the year-end rush. The cargo ship effort continued to decline through May, June, and July of 1944 because of the diversion of more and more effort into tanker construction; keels for 11 of the 13 completed TA tankers were laid in those 3 months. The net decline from April to July in the total steel ship construction effort may be attributed to the interruptions and delays arising from the shifts in production program from cargo to tanker types. After the effort on tankers reached its peak in July, it tapered off gradually during the ensuing three months through October. In the meantime the cargo ship effort recovered considerably so that in August and again in October the over-all effort on steel ships exceeded that of any previous month except January 1944.

While steel ship production was being maintained throughout the summer and fall of 1944, as if by forced draft effort, the wooden ship production effort rose gradually from January to its slightly higher all-time peak in May 1944, then fell away rapidly, especially in July and August.

The shipbuilding industry as a whole may be said to have been operating at the maximum rate achieved during the entire war from January through May of 1944. The portion of the industry engaged in steel ship construction continued its maximum level of effort, except for losses due to shifts in type of ship built, through October 1944.

While the over-all shipbuilding effort required only 15 months to increase to 6 times its original size, during the 10-month period following October 1944, it had fallen to between one-twelfth and one-eleventh of the October scale of effort. The sharpest drop was from February to March 1945, when tanker construction was virtually abandoned and cargo construction took its first severe cut. From March to the end of the war, effort was little more than nominal in any line but cargo ships. Even in that line the rate of decline indicated that significant effort could not be continued more than 2 months at most.

Ships which had been started as tankers in November and December were later scheduled for completion as cargo ships after January. This explains the sharp decline in tanker construction which occurred during November, despite the delay until January in the decision to stop tanker construction. The change in type resulted, in this study, in their being classed retroactively as having been cargo ships throughout the period of their construction.

VI. BOTTLENECKS

Inherent Limitations

The comparatively undeveloped technological methods of ship construction employed by the Japanese, even in the newest and best of their shipyards, imposed a much slower, less efficient rate of production in terms of manpower and raw materials than was achieved in the United States. There can be no comparison between the output that could be expected from a given commitment of manpower and raw materials in the shipyards of the two countries. The difference in technology was such that continued applications of manpower and materials during a given period in any of the Japanese yards would cease to bring a material increase in tonnage, while an American yard with comparable capital investment would still be producing at a rate considerably below capacity. Hence, it would be useless to estimate what Japanese production might have been in terms of American rates of production. Such rates could not have been achieved even if the other bottlenecks could have been removed.

These technological limitations indicated in Chapter III, consisted of such shortcomings as the congested and unsystematic shipyard layouts, the lightweight equipment inadequate for extensive ship section fabrication and preassembly, and poorly developed techniques for cutting and welding plate. Such limitations arose from the lack of foresight and creative engineering on the part of shipyard operators and responsible government agencies and from

a comparatively low level of skill on the part of the average Japanese shipyard workers.

Closely related to the technological limitation and similarly inherent as a limitation on production regardless of the more variable factors, was the confused and ineffectual character of the administration and supervision of the shipbuilding program.

In the early stages of the war, there was no civilian government authority strong enough to provide effectual control of the program. The Ministry of Transportation and Communication did not have the staff, the imagination or the prestige to promote a large scale expansion in merchant shipbuilding. Schedules and ship designs were established largely at the behest of the large commercial shipbuilders and no new large yards independent of the established producers were fostered. No civilian authority existed in the Japanese Government which could stand up to the army or navy in the scramble for raw materials and production capacity. As a result, allocations to merchant ship construction had to be made from what remained after the armed forces' programs were satisfied.

When the navy finally took over the control and responsibility for the merchant ship program many of the weaknesses of the civilian control were overcome. The Navy Technical Bureau had the staff, technical competence and prestige to initiate changes in the schedules and ship designs. Also, having the responsibility for getting volume production, the navy was compelled to make important sacrifices in its own program in order to meet new obligations. Even the navy administration, however, had the shortcomings and weaknesses characteristic of most Japanese administration. Priorities, schedules, materials and labor allocations and similar administrative decisions were born of compromises, were more or less ambiguous, and were constantly undergoing changes. Adherence to these measures was not always persistently enforced; in too many instances such decisions were made when it was known that they could not be made to stick.

Delays in Expansion Prior to Peak Effort

Several factors limited the expansion of shipbuilding at the outset, but were at least partially overcome and amounted, therefore, to delays in the program rather than over-all bottlenecks.

The Japanese were slow to recognize the magnitude of the demand for new tonnage that continued prosecution of the war would require. This lack of appreciation of the urgency of the program contributed to the delay in expanding the program to the extent that ultimately was attained. If the urgency had been recognized sooner, the transfer of control to the navy, the reduction in number and greater simplification of the standard ship designs, the construction of new shipbuilding capacity and a greater sacrifice of competitive demands might all have been accomplished sooner with a consequent large increase in production at an earlier date.

Competitive demands for raw materials and production capacity held such priority for a full year after the outbreak of war that no material increase in merchant shipbuilding was possible during that period. The most serious diversion, as has already been shown, was the preoccupation of several of the largest commercial yards with heavy naval ship construction.

Finally, one of the most serious factors delaying the increase in the rate of shipbuilding was the delay in the expansion of existing yards and, even more serious, the delay in construction of new yards. As shown on Chart 4, page 12, the over-all expansion in gross floor space from 31 March 1942 to 15 August 1945 was 78 percent. The timing and distribution of that expansion between old and new yards is shown by the following percentages of the over-all total:

Fiscal year	1942	1943	1944	1945	Duration
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Old yards	12	21	16	8	60
New yards	2	23	12	3	40
All yards	14	47	28	11	100

Keels were laid for regular production in one of the four new E-type building yards in April 1943, in another in May and in the remaining two yards in June 1943. First keels in the Hiroshima-Mitsubishi yard, the A-type builder commenced in 1943, were laid in December of that year. The first A-ship keel laid in the new Kanagawa-Hitachi yard was put down in June 1944. The failure of these 2 yards to deliver more than 35,000 tons of A-ships in 1944 accounted for 130,000 tons or

26 percent of the deficit of A-ship deliveries below the amount scheduled for 1944 in the April 1944 plan. In this instance, then, the effect of the delay in the construction of these new yards not only was a delay in the increase in the volume of production but also carried over as a limitation of the peak of production attained by the industry when it was most fully extended.

Industrial Capacity and Peak Production

The amount of physical plant available for operation, the technological capabilities of the existing plant and the administrative competency of the control of the industry together constitute the industrial capacity limitation on the rate of production attained by the shipbuilding industry during the period of peak production. The other bottleneck factors simply constituted delays in the growth of the rate of construction, inasmuch as they were largely overcome in the process of reaching the peak. But none of the aforementioned factors could have been responsible for the precipitous decline in the rate of production, or they would have prevented the attainment of the peak. The new bottlenecks responsible for the large decline in production also may have been felt sufficiently during the period of peak production to have prevented the full utilization of the industrial capacity for shipbuilding even during the peak period. The extent to which the full industrial capacity was utilized during the period of peak production must await analysis of the new factors that caused the decline.

Several methods are available for ascertaining the capacity of the industrial plant in existence at a given time. A direct assessment of capacity would require two steps. First, an engineering estimate would have to be made of the maximum rate of production in each existing shipyard of the type of ship for which the yard was best fitted. These estimates would have to take into account the technological limitations of the yard and its operators. Finally, an appropriate allowance on an industry wide basis would have to be made for interruptions and inefficiencies imposed on the yards by changes in specifications and the multitudinous slip-ups characteristic of Japanese administration. The time available in Japan did not permit a systematic evaluation of either of these steps.

Another basis available for ascertaining capacity is the maximum construction effort scheduled by the Japanese for each of the shipyards. Aside from the practical difficulty of determining whether additional yard expansion was contemplated by the schedule makers before the scheduled rate was to be attained, there are the theoretical objections to scheduled production as a measure of capacity. Undoubtedly, the maximum scheduled scale of effort included, for purposes of creating incentives, a margin the realization of which the planners themselves actually did not anticipate. Furthermore, the advance scheduling could not anticipate the interruptions and inefficiencies imposed by changes in plans and other controlling circumstances that actually materialized to limit the capacity.

The only satisfactory available measure of capacity is the actual effort expended during the period of peak shipbuilding activity. The chief reservation in making that use of the peak rate of production is the extent to which the factors that later precipitated the steep decline may already have been felt in sufficient force during the peak production period to have limited the production effort short of actual capacity. Whether or not this was the case and the extent of the unused capacity if there was any are considered after a discussion of the production factors responsible for the decline.

Steel Supply

The increase in the share of the Japanese war economy dedicated to merchant ship construction is indicated by the sharp increase in the share of available steel assigned to that effort. The desperate effort to maintain ship construction despite the decline in available steel in the later stages of the war is manifested by the continued increase in the fraction of steel deliveries channeled into merchant ship construction even after steel production had begun its decline. The relationship of steel delivered for work on merchant shipping to total steel deliveries and production is shown in table 5, page 32. The data are taken from Appendix Tables 12 and 14 of the report of the Basic Materials Section on Coke, Iron and Steel.

TABLE 5.—*Relative importance of steel for merchant ships*

Fiscal year	Total finished steel		Steel for merchant ships		
	Delivered 1,000 metric tons	Produced 1,000 metric tons	Delivered 1,000 metric tons	Percent of total delivered	Percent of total produced
1941	5,454	5,120	372	7	7
1942	4,881	5,166	536	11	10
1943	5,554	5,609	920	17	16
1944	4,761	4,320	1,324	28	31
1945 (First quarter)	729	492	228	31	46

The desperate character of the ship building effort in 1944 is shown by the fact that the steel delivered for the purpose was increased by more than 400,000 metric tons in spite of over-all decreases of almost 1,300,000 metric tons in total steel production and 800,000 metric tons in total deliveries in Japan.

Approximately five-sixths of the steel used for merchant shipping throughout the war went into new ship construction. The slight decline was largely absorbed by the portion going into ship repair, which increased steadily from 8.3 percent in 1941 to 9.2 percent in 1945. The remaining one-fifteenth in all years was devoted to the expansion of the commercial yards. Hence, the absolute changes in the quantity of steel available to the industry were largely reflected as changes in the steel available for new construction.

As shown in Table 5, the steel industry in 1944 began drawing steel for deliveries from its stock pile faster than new production could replenish it. In that same year the consumption of rolled and special steel for ships and their engines outstripped deliveries of such steel to the commercial yards. This process of decreasing the amount of steel in both sections of the "pipe-line" increased materially in 1945. This shift in balance between average monthly steel delivery and consumption for merchant ship construction in each fiscal year is shown in Table 6, page 32, along with the resulting change in the average inventory and the period of its turnover.

TABLE 6.—*Average monthly deliveries and consumption and average inventories of rolled special steel in merchant ship construction by fiscal years—1,000 metric tons*

Fiscal years	1942	1943	1944	1945
Average monthly deliveries	32	56	84	40
Average monthly consumption[1]	29	50	85	57
Average inventory[2]	222	274	305	263
Percent consumption of delivery	91	89	101	143
Average turn-over period	[3]7.6	[3]5.4	[3]3.6	[3]4.6

[1]Consumption and inventories reported by shipyards are increased 7 percent or less to bring resulting elivery totals into line with over-all delivery figures reported to Basic Materials Section of USSBS. The difference could be accounted for by incomplete returns from the shipyards.

[2]Average of beginning and closing inventories.

[3]Months.

The extent to which the steel position became progressively tighter up to the time of peak production in 1944 is shown by the fact that the average number of months steel supply on hand was cut by more than one-half between 1942 and 1944. With a rapid increase in the rate of ship construction, a considerable reduction in the proportion of the inventory to the consumption of steel is possible without interference with production. Thus, the increase in inventory between 1942 and 1943 was about one-third the increase in the rate of consumption. Between 1943 and 1944 the increase in inventory was only one-sixth of the increase in consumption, resulting in an average inventory turnover period of only 3.6 months or 108 days during the peak year of operations. The average of the building period per ship for each type of ship weighted by the tonnage of each type delivered was 113 days. The average inventory on hand in 1944, therefore, was less than enough to complete one round of ships at the rate of ship production and steel consumption prevailing in 1944. Uninterrupted ship construction with so nearly a hand-to-mouth steel position would have required administrative organization and flexibility superior to that demonstrated by the Japanese. The statement by the Navy Technical Bureau is confirmed, then, that principal limiting factor on production at the peak was the limited supply of steel.

By 1945 the average monthly deliveries of steel to the shipbuilding industry had fallen to less than half the average rate in 1944, while steel consumption had fallen to two-thirds the 1944 rate. Since the fiscal year 1944 includes 5 months in which the economic input was on the downgrade, the 1945 averages would be a still smaller fraction of the rates of delivery and consumption during the 7 months of peak activity in 1944. These data show that a drastic deterioration of the steel position at least accompanied the precipitous decline in input and created the presumption that the failure of steel was at least one principal cause of the decline in the shipbuilding effort before widespread air attack began. Whether steel was the principal cause of the decline must await the analysis of other possible factors in the decline.

The marked increase in 1945 in the period of turn-over resulted from the fact that the average rate of consumption fell off between 1944 and 1945 even faster than did the average inventory. Assuming that steel consumption in August related to that for all of fiscal 1945 up to the end of the war in proportion to the corresponding ratio of economic input in shipbuilding, steel consumption had fallen off to the point where the inventory on hand at the end of the war would have supported operations for 8.2 months. In other words, while 20 percent of steel consumption for shipbuilding came from net drawdowns in inventories during 1945, the rate of production was falling off so fast that the remaining inventories reassumed adequate or even more than adequate proportions. It is likely that inventories were badly out of balance in the summer of 1945, but not so much so that a higher level of production could not have been supported. Factors other than an immediate steel shortage were forcing production down at a rate rapidly approaching zero.

Labor Supply

The over-all labor supply was never a primary bottleneck in merchant ship construction although it was under a considerable strain during the period of peak production. The fact that the decline in construction activity came so much sooner and faster than the decline in the labor supply indicates conclusively that some other factor in production was responsible.

The quantity of labor supply utilized is most clearly reflected in man-hours worked. The adequacy of the labor supply is most clearly reflected in the relationship of man-hours worked and the total productive effort. The relative strain or relaxation of demand for labor is reflected by the relationship of man-hours worked and the average number of employees which, on a monthly basis, would reflect changes in the standard hours per day or days per months or in the amount of absenteeism.

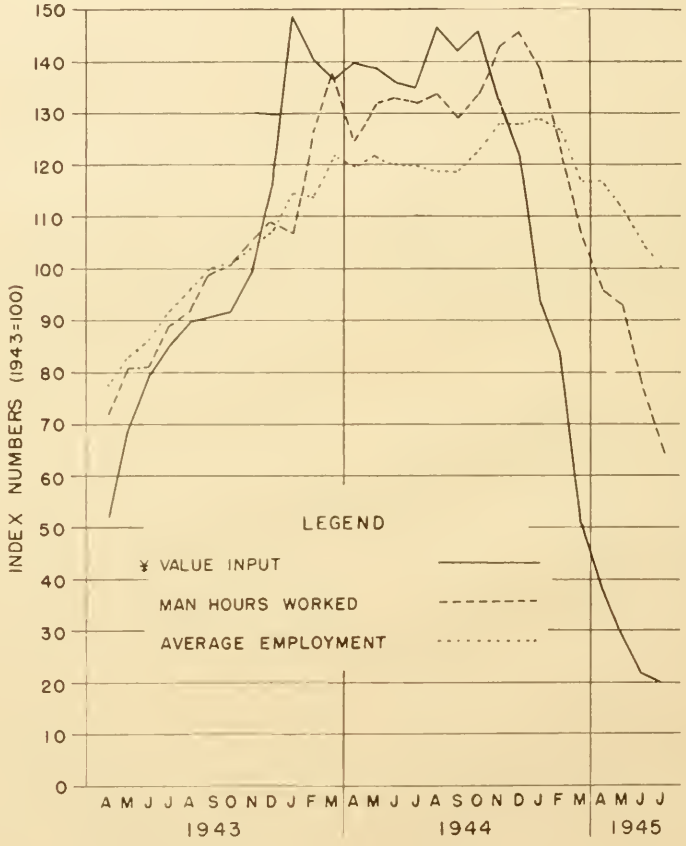
The presentation of the monthly indexes of yen value input, of man-hours worked and of average employees engaged in the construction of steel merchant ships on Chart 9, page 34, permits the comparisons mentioned above. The average monthly amounts for the fiscal year 1943 equals 100 for each index.

The interrelationships of production effort and labor supply, shown on Chart 9, passed through four significantly different phases, the first of which included an exceptional variation. The first phase was the 13-month period April 1943 through April 1944, during which the shipbuilding effort was undergoing a rapid and continuous expansion. The exceptional efforts of the high-pressure production speed-up at the end of the fiscal year appear in January, February and March 1944 during the period. In the second phase, from May through October 1944, a peak level production plateau was sustained, but with greater exertion on the part of employees than was characteristic in the earlier period. From November 1944 through January 1945, production declined sharply almost to the average for 1943, despite peak applications of the labor factor both in terms of employees and man-hours worked. During the final phase from February through July 1945, the labor factors declined, but the production effort continued to fall off at an even more rapid rate.

The increase in economic input between April 1943 and April 1944 was about twice the increase in average employment at the same time that average man-hours per employee increased only about 20 percent. This indicates that the additional physical plant and simplification of the design of ships produced in old and new yards alike resulted in increased labor productivity and may, therefore, be considered the principal controlling factors in the volume of production during this period of continued expansion in shipbuilding activity.

With the exception of the year-end rush in February and March 1944, it was not until May 1944 that the trend in man-hours increased materially over the trend in average employment. The exceptionally large margins of man-hours over employment in the year-end months of February and March represent the longer hours worked to complete ships before the March 30 fiscal deadline. The fact that the input curve shows the peak of this year-end activity to have been in January arose from the overlapping of ships about completed with the extra number of ships started for the year-end rush. The large increase in average man-hours per employee in March indicates that an equal allocation of the work on a ship over the months the ship was under construction is not in this

INDEXES OF ¥ VALUE INPUT, MAN HOURS WORKED AND AVERAGE EMPLOYMENT IN THE CONSTRUCTION OF STEEL MERCHANT SHIPS BY MONTHS, APRIL 1943 - JULY 1945



U S STRATEGIC BOMBING SURVEY

JAPANESE MERCHANT SHIPBUILDING

CHART 9

instance an accurate reflection of the distribution of economic input. In any event, the fact that a near peak production rate was maintained in April 1944 with the comparatively slight increase in man-hours per employee over the average prevailing during 1943 indicates that, except for the exceptional year-end surge, the peak plateau of production prevailing from January to October 1944 was reached without a great strain on the labor force. Hence, it may be concluded, the attainment of that level of production was not seriously retarded by any shortage of labor supply.

Beginning in May of 1944, however, the maintenance of the peak level of productive effort through October 1944 did require a significant and sustained increase in hours per employee. This indicates the labor situation was significantly tighter during this period than it had been during 1943. That the total input increased more during this period than did the total man-hours indicates the labor supply, at least up to the August-October production peak, had not been a primary limiting factor in production. The fact that a materially higher labor supply both in terms of man-hours and employees was applied in December creates the presumption that it could have been applied between August and October if it had been required during the peak production period.

By January 1945, the end of the third phase, production had fallen steadily to less than two-thirds the production in October 1944, despite the fact that in November, December, and January both employment and man-hours were maintained at unprecedented peak levels. This indicates a frantic but futile effort to maintain the rate of ship production in the face of the severe steel shortage that made itself felt most keenly during this period.

Apparently the futility was reflected back into the labor effort in February because, for the first time in more than a year, the average hours worked per employee fell below the average for fiscal 1943, thus marking the beginning of the final phase in the interrelationships among the labor factors and production. By July 1945, the end of the period under analysis, average employment had fallen steadily to the 1943 average. The increase in absenteeism in the shipyards, due primarily to urban area incendiary attacks and food shortages, resulted in a steady but more rapid decline in man-hours worked to a level in July 1945 slightly below the lowest in fiscal 1943. But these declines in the labor supply cannot be held responsible for the decline in production, because that was even more drastic throughout the period, ending in July at only one-fifth of the average for fiscal 1943 and two-fifths of the lowest in that year.

The quality of the labor in the commercial shipyards of Japan, although never good enough to permit the use of many technological improvements known to the Japanese, deteriorated rapidly during the last 12 months of the war. Experience varied considerably among the yards but in some the number of regular employees had been cut to less than one-third the prewar level in the late fall of 1944 as a result of the draft for the armed services. This process was accentuated during the last year of the war as the Philippine, Iwo Jima, and Okinawa campaigns brought the war closer and closer to Japan. In the meantime, the labor force in the shipyards was maintained and even increased by the assignment of one or another of the various classes of compulsory labor. The average composition of the labor force of eight representative large yards during October and November 1944 was as follows:

	Percent
Conscripted Japanese Labor	45
Regular employees	20
Students (mostly boys)	10
Civil prisoners (Japanese)	9
Korean conscripts	8
Women (mostly clerical)	4
Prisoners of war	3
Chinese conscripts	1
	100

The conscripted labor was generally low-quality unskilled labor with little or no mechanical experience. The Japanese conscripted labor, composing almost one-half of the entire labor force during this period, consisted of unskilled males unfit for military service who had been brought in from the agricultural regions of Japan.

The necessity of relying increasingly on such low grade labor provided many headaches for the shipyard managers and the resulting rate of production was, no doubt, lower than would have obtained with higher grade labor. But inasmuch as this substitution of low grade labor was well under way before October 1944 and

up through that month, productivity had actually been increasing, it cannot be concluded that the low quality of labor precipitated the steep decline in production that continued from October to the end of the war.

Components Supply

The most important ship component requiring advance manufacture is, of course, the ship's engine, including the boiler for steam-driven engines. Generally speaking, the production of ship's engines kept apace the production of hulls.

As mentioned on page 6, 60 percent of the wartime horsepower production of merchant ship engines came from 5 producers, while the remainder was divided equally between the 10 next largest producers on the one hand and the remaining 59 producers on the other. All of the 15 large producers were commercial shipyards except the two Hitachi engine plants, one at Hitachi and one in Tokyo, which were owned by one of the industrial combines heavily engaged in shipbuilding. Practically all of the turbine and reciprocating engines and the boilers for ships larger than type D were built in these 15 establishments. The myriad nonshipyard enginemakers, ranging in size from comparatively small to tiny, were engaged primarily in making Diesel engines for the type-E ships and were the principal source for that type of engine. None of the four new yards specializing in E-ships made their own engines.

Comparison of the dates that engines were available at the shipyard with dates of launching show only occasional delays in the delivery of the larger types of ships attributable to delay in engine production. A greater degree of difficulty was experienced with E-type engine deliveries, but by the time this became serious in the spring of 1945 the production of E-type ships had been reduced and such as were scheduled were to be equipped with coal burning reciprocating machinery because of the scarcity of Diesel oil. Hence, a new set of producers, principally smaller commercial shipyards, were called upon for engines for this class and engines were supplied as rapidly as the hulls were built.

These Japanese shipyard officials who were interrogated stated that engine deliveries held up construction in some instances, but were not generally an important factor in the slow-down of the construction program. Neither was any crippling over-all shortage of any other ship component reported.

Although irregularities in the flow of components to the fitting quays effected occasional delays in ship construction, there was no overall shortage of ships engines or other components relative to the volume of shipbuilding permitted by other limiting factors.

Bottlenecks in the Wooden Ship Construction Program

The very poor showing made in wooden ship construction up to the summer of 1943 was due to the difficulties and delays in building new yards, in obtaining priorities and establishing channels for timber, steel and labor and in strengthening the administrative machinery for control of the standard ship program.

By December 1943 the capacity to produce wooden ship hulls had so increased that the demand for engines could not be satisfied by the haphazard system under which their production had been administered. Hence a system of close coordination of engine procurement with the performance in hull construction in the various yards was inaugurated by the Transportation Ministry which was also able to secure better steel priorities from the navy for engine production. Relieved of the bottleneck on steel and ship's engines, wooden ship production quickly rose to a peak plateau which lasted through June 1944.

The supply of timber and labor for hull construction were the primary limiting factors on wooden ship construction during the peak period from December 1943 through June 1944. The timber difficulty lay principally in the shortage of labor to cut it and in the extreme difficulty of transporting it to the shipyards. The yards with the best production records during this period were the yards that owned and cut their own timber at sources close to the shipyard. The fact that the wooden shipbuilding yards were never assigned conscripted labor as were many of the larger industries was only partially offset by the fact that they were small, widely scattered enterprises located, for the most part, outside of the large industrial centers of Japan and could, therefore, draw from local labor supplies. In general they could not obtain enough help to sustain the maximum rate of production possible during the period when

steel was available to the industry in fair supply.

Most of the steel supply which had been marshaled for engine construction in the spring of 1944 was exhausted by the end of June and the general supply of steel in Japan had become so short by that time that the Transportation Ministry was unable to secure more steel. The administration of wooden ship engine production was, therefore, transferred to the Navy Technical Bureau in July 1944. Even with the higher priorities at the navy's command, however, steel was not obtained in sufficient quantity to prevent the sharp decline in engine production and hence in wooden ship production which set in during July 1944 and continued to the end of the war.

Summary of Bottleneck Factors

In several instances final evaluation of various bottleneck factors were deferred until the other factors were discussed. The over-all limitations of Japanese administrative capacity, both industry wide at the government level and internally at the plant level, and the over-all technological limitations imposed by the limited skills of the average Japanese shipyard worker applied throughout the war. Within those limitations the primary controling factor shifted from time to time.

During the years immediately preceeding the outbreak of the war and thereafter until November 1942, merchant shipbuilding had only a moderate war priority and was limited primarily by the absorption of much of the existing capacity in naval ship construction.

Inspired by the unexpected rate of losses of merchant ships and the increased civilian and military demand for them, priorities were raised on merchant ship construction and curtailed on naval ships. As existing shipyard capacity became absorbed in merchant ship construction, the design of the ships was simplified, permitting a greater tonnage production by the existing plant, and new facilities were created by the expansion of existing yards and the construction of new yards. During the period of the rapid increase in the rate of production from November 1942 through December 1943, the capacity of the physical plant in operation constituted the primary limitation on the volume of effort in the construction of steel ships. In the case of wooden ships, production was held below the capacity of the physical plant throughout the period of expansion because of the tardiness in securing steel sufficient to provide engines for all the wooden ships that could be built.

The high rate of turnover of steel stocks during the period of peak activity (from January through October 1944) in the construction of steel ships combined with the testimony of many Japanese shipbuilders indicates that a shortage of steel was the primary factor which prevented the realization of the full production of which the yards then in existence were capable. Although the labor force then at hand worked at a considerably stepped up pace, the fact that a greater labor effort was commanded after the decline in production set in may be taken as evidence that it might have been even greater than it was during the period of peak activity had circumstances warranted it. The comparatively slight valley during June and July in the plateau of peak activity resulted, at least in part, from the scheduled adaptation of many type A hulls to be completed as type TA tankers.

The level of activity in the steel shipbuilding industry during the period of peak production may be summarized, then, as having been somewhat less than the technologically limited capacity of the existing physical plant primarily because of the shortage of steel; at the same time the labor supply was under such a strain that, had steel sufficient for full production been available, the labor supply would have had to be argumented as well. The margin between the actual production achieved in this period and that which might have been achieved with more steel and labor was not great in comparison with the volume of production actually achieved. In itself, it probably could not have been great enough to materially alter the course of the war. In contrast to steel ship construction, the limitation on wooden ship production during the period of its peak activity was not steel but timber and labor supply. Once it exhausted the steel alloted to it, however, the period of peak activity came to an abrupt conclusion. The fact that this occurred in July 1944 while steel ship construction activity was sustained at peak through October illustrates the extent to which the steel priority for merchant shipping of sizable tonnage was being raised in a desperate attempt to obtain mer-

chant shipping despite Japan's increasingly impossible over-all steel position.

For merchant ship construction the bubble finally burst in October 1944 and despite heroic increases in the labor supply, both employment and working hours, production started skidding in November 1944. By the end of February 1945, before the delivery of any air attacks materially affected the industry, production had fallen well below the average for the fiscal year 1943. The decline was the direct result of the exhaustion of the steel supply. A corresponding decline in wooden ship construction due to lack of steel for ships engines had set in in July.

During the period from March 1945 to the end of the war shipbuilding activity, both steel and wood, continued to fall at a rate which would have practically ended shipbuilding if the war had lasted 2 more months. The decline in employment and average manhours worked during this period was much less rapid. The over-all steel inventory in the shipyards at the end of the war, even allowing for unbalance in the assortment of shapes, could have supported a higher level of shipbuilding activity than prevailed during the last few months of the war. Further analysis of the decline must await analysis of the effects of air attacks.

VII. EFFECTS OF AIR ATTACK

Status of Shipyards as a Target System

Commercial shipyards in Japan held a comparatively low priority as a target system for Allied air attack. The Joint Target Group designated 18 commercial yards as major targets, but recommended against attack on the system. Neither the Twentieth AF nor the navy planned any systematic attack on the yards.

A single navy TBM attacked the Kobe-Mitsubishi yard on 19 March 1945, and a single B-29 dropped 5 tons of HE on the same target on 24 July 1945. Other than these, the only attack aimed specifically at a shipyard was delivered by the Seventh AF before dawn on 1 August 1945, when 6 B-24s dropped 19 tons of HE on the engine works at the Nagasaki-Mitsubishi Shipyard. That particular target carried a No. 4 priority for this, the only multiplane mission directed at a commercial shipyard in Japan during the entire war. Since that attack was delivered approximately 2 weeks before the end of the war, its effects on the volume of wartime shipbuilding were confined to the damage done to vessels present at the yard during the attack. It may be concluded, therefore, that there were practically no direct attacks aimed specifically at shipyards that interfered materially with production.

There was, nevertheless, considerable direct damage inflicted upon commercial shipyards by Allied air attack. Most of this damage occurred in those yards situated within the large urban areas and was inflicted by the incendiary attacks on these urban areas. In such attacks the shipyards along with all the rest of the urban areas was the target.

A considerable amount of damage was done to shipyards in attacks the target of which was the shipping at or near the shipyard. The Twentieth and Fifth AF dispatched several such attacks and the navy carrier planes, both American and British, made a substantial number of such sorties. Incidental damage of this sort occurred at several of the large isolated shipyards in the Inland Sea which were otherwise untouched during the war.

A few yards suffered damage from HE bombs aimed by Twentieth AF planes at nearby industrial installations. The Nagoya Shipyard, a Class 5 yard, suffered serious damage when the nearby Mitsubishi Aircraft Engine Factory was attacked on 18 December 1944. The Tsurumi Shipyard of Japan Steel Tube, a class 3 yard, suffered several hits when the nearby Kawasaki Petroleum Complex was attacked on 1 August 1945.

Although shipyards were assigned a low priority for air attack, shipping continued to carry a high priority as a strategic target when the home islands were within range, just as it had before that time. One of the most effective instruments in the air attack on shipping in Japanese home waters was the B-29 mining campaign. The analysis of the air attack on shipping, including the effect of the mining campaign, is given in the report of the Transportation Section of the USSBS. However, inasmuch as the mining campaign damaged a great many ships that did not sink, it created considerable additional demands on the shipyards near the affected areas and thereby affected the ability of those yards to maintain their rates of new construction.

For purposes of analysis, the effects of air attack are classified into three categories bearing on the ability to sustain over-all shipbuilding activity and an additional category covering the effects of air attack on the demand for shipyard services. The three supply-side categories treat separately the effects of damage in the shipyards, damage to other targets, and interference from activity in anticipation of air attack, respectively.

Effects of Damage to the Shipyards

By the end of the war more than 7,700,000 square feet of the floor space of buildings in the commercial shipyards, or 24 percent of the total that would otherwise have been in existence, had been destroyed by air attack. Of the 50 yards reporting on floor space, 17 received no damage, 9 lost less than 10 percent, 15 lost between 10 and 50 percent, and 9 were more than half destroyed. The timing of the damage as measured by floor space destroyed is shown in the following percentage distribution by months of the total loss of floor space:

		Percent of total
December	1944	1
January	1945	—
February	1945	(1)
March	1945	39
April	1945	1
May	1945	12
June	1945	17
July	1945	12
August	1945	18
		100

[1]Less than 1 percent.

Since production for the year 1945 would not have been affected materially by the damage done in July and August, evidence of the affect of the damage on production must be sought in the 1945 record of production in those yards which were damaged during or before June 1945. Of the 50 yards reporting on floor space, 17 had lost more than 10 percent by air attack before the end of June. An indication of the effect on production brought about by the air attacks delivered before the end of June is given in Table 7. Here a comparison is made of the change between 1944 and 1945 of the average monthly value added in all work on naval and merchants ships and ship components in the 17 yards damaged significantly before July with the comparable change in the same measure of production for the 32 yards not so damaged.

TABLE 7. — *Effect of bombing on average monthly value added during 1945[1] in all work on merchant and naval ships and ship components in the commercial shipyards in Japan*

Damage status of shipyards	Average monthly value added ($1,000)		Index 1945 (1944 = 100)
	1944[2]	1945	
Undamaged yards[3]	75,265	51,246	68
Damaged yards[4]	49,077	23,114	47
All shipyards	124,342	74,360	60

[1]The "year" 1945 for 32 of the shipyards was from 1 January through 15 August. For 11 others it was from 1 April through 15 August, and for 6 yards it was for the portion ending 16 August 1945 of some other fiscal year.

[2]Adjusted to 1945 prices (118 percent of actual 1944 values).

[3]Includes 32 yards producing 60 percent of the 1944 production which were untouched or had lost less than 10 percent of their floor space by bombing before 30 June 1944.

[4]Includes 19 yards producing 40 percent of the 1944 production each of which had lost more than 10 percent of its floor space by bombing before 30 June 1945. Total floor space lost by these yards as of 30 June amounted to 36 percent of the total that would have otherwise been in existence in these yards.

An indicated loss of 21 percent of the average monthly production in 1945 in the 17 damaged yards presumably occurred after the attacks in March, May, and June. Inasmuch as most of 17 yards reported on the calendar year, a considerable period of undisturbed production had elapsed before the attacks were delivered. It follows that the reduction in activity in these yards after the attacks was considerably more than 21 percent. The loss of 36 percent of the total floor space in these 17 yards includes, in the case of Yokohama-Mitsubishi, Ishikawajima and to a lesser extent in others, the loss of workers' dormitories and service facilities which should not have interfered with production as would the loss of the same amount of factory floor space. Despite the substantial but far from hopeless degree and kind of damage sustained by these yards, however, production apparently underwent a marked and permanent slump in these yards.

Reconstruction and recuperation from damage inflicted by air attack was very slow and very limited in these yards. Replies to the questionnaire on the subject consist largely of nonspecific but heroic phrases. Inspection of many of the yards in different parts of Japan revealed that measures had been taken for only the most easily repaired damage to the most vital equipment; practically no seriously damaged buildings had been replaced or restored. The lack of physical recuperation confirms the reported serious loss of worker morale following substantial air attack damage to the yards. Even more important, it also confirms the impression that, on the whole, Japanese

shipyard management was not sufficiently versatile to overcome the disruptions and irregularities imposed by the air attack damage to the extent necessary for a reasonable recovery of productive activity. It may be concluded, then, that any substantial amount of physical damage to the average shipyard was enough to effect a considerable and comparatively permanent reduction in productive activity in that yard.

Damage from air attack was reported from only 41 wooden ship construction yards, or 16 percent of the total of 548 such yards in Japan. About half of those damaged were totally destroyed. Several were damaged in March 1945, but more than half of those damaged were attacked in July and August. Most of the yards affected were damaged in the urban areas attacks or in attacks on the wooden ships in or near the yards. By the time the attacks were delivered, production of wooden ships had fallen off to such an extent because of the lack of engines, that it is doubtful that the damage inflicted on the comparatively small fraction of all the shipyards materially affected the volume of wooden ship construction.

Effects on Shipbuilding of Damage to Other Targets

The effects on shipbuilding of the damage inflicted by air attack on the portions of the economy that support shipbuilding are difficult to measure because they are largely merged with all other factors that affect the volume of support. For example, it is difficult to say how much of the shipyards' labor difficulty was due to absenteeism traceable to air attack, to absenteeism attributable to other causes, or to the reduction in average skill of the labor force on hand because of the drafting of the more able men into the armed services. What can be said of the effects on shipbuilding of damage to other targets may be separately discussed in terms of the effects on labor force, components supply, and materials supply, respectively.

Testimony of shipyard managers indicates that two factors were primarily responsible for the reduction of the quantity of the labor force applied in shipbuilding during 1945—absenteeism from the yards in areas affected by the urban area raids resulting from the destruction of homes, interruption of local transportation, etc., and absenteeism from all yards resulting from the food shortage causing employees to go into the rural areas several times each week in search of food. No complaint was heard of a shortage of employees on the pay rolls. That the decline in manhours was considerably more serious than the decline in employment is borne out by the fact that computed on the same time basis as the production rates shown in table 7, page 91, the average monthly employment in 1945 was 92 percent of that for 1944 while the comparable ratio for manhours was 74 percent.

The fact that the average monthly rate of production in 1945 had fallen to 60 percent of the 1944 rate, while manhours and employment had fallen only to 74 and 92 percent, respectively, indicates that some factor other than absenteeism, as bad as it was, was a more potent cause of the decline in over-all shipyard activity. This point is emphasized by the comparison made in Table 8, of the production and labor force experience of the undamaged shipyards located in cities subject to area raids before 30 June with that of the damaged shipyards and that of the undamaged shipyards located in unattacked areas.

TABLE 8.—*Effect of bombing on average monthly production, manhours, and employment in 1945[1] in damaged yards, undamaged yards in attacked areas, and undamaged yards outside attacked areas*

Damage status of shipyards	Damaged yards[2]	Undamaged yards in attacked areas[3]	Undamaged yards in unattacked areas	All yards
Monthly average amounts:				
Production (=1,000)[4]:				
1944	49,077	9,025	66,240	124,342
1945	23,114	6,961	44,285	74,360
Man-hours (1,000):				
1944	12,720	2,243	18,579	33,542
1945	7,380	1,147	16,237	24,764
Employment (100):				
1944	1,099	145	1,436	2,680
1945	952	123	1,380	2,455
Indexes, 1945 (1944 = 100):				
Production	47	77	67	60
Man-hours	58	51	87	74
Employment	87	85	96	92

[1]The "year" 1945 for all computation in this table is the same as for Table 7, page 39.
[2]The damaged yards in this table are the same as in Table 7 page 39.
[3]Includes six yards producing seven percent of 1944 production which were undamaged as defined in Table 7, page 39 but were located in cities subjected to 1-Burban area attacks prior to 30 June (Tokyo, Kawasaki, Yokohama, Nagoya, Osaka, and Kobe). The 1945 production indexes for these yards in the order of their 1944 production volume were 84, 150, 54, 67, 250, and 946.
[4]Includes twenty-six yards producing fifty-three percent of 1944 production which were undamaged as defined in Table 7, page 39, and were located outside areas attacked prior to 30 June.
[5]Average monthly value added in all work on merchant and naval ships and ship components.

While the undamaged shipyards in the urban areas which were attacked suffered a somewhat greater decline in manhours and employment than the damaged yard, their production declined significantly less than the undamaged yards which were not in the vicinity of area

attacks. This constitutes a clear indication that it was not labor shortage that reduced activity in the damaged yards, and created the presumption that it was the physical damage within the yard itself that brought about the decline.

Data on the volume of ship components production outside shipyards are not available in sufficient detail to reflect any effects of air attack on nonshipyard producers. The extent to which both damaged and undamaged shipyards maintained components production in 1945 much better than work directly on ships is shown in the following tabulation:

[Indexes, 1945 (1944 = 100)]

Yards	Components production	Work on ships
Damaged	70	40
Undamaged	81	66

The increased emphasis in 1945 on components production in the shipyards shown in the tabulation indicates increased difficulty in securing components from nonshipyards producers. Such difficulty undoubtedly was caused in part by air attack damage to such producers. In view of the fact that the shipyards, including those damaged by air attack, were able to sustain a comparatively high rate of components production in 1945, and in view of the fact, stated on page 6, that 74 percent of the total horsepower of merchant ship engines produced during the war was produced in the commercial shipyards, it is not probable that a shortage of components was responsible for the reduction in the rate of ship construction in 1945

As shown in the report of the Transportation Section of USSBS, the tightening of the shipping blockade in May, June, and July 1945 by increased air attacks on ships in Japanese home waters and by the B–29 mining campaign made it increasingly difficult to produce steel in Japan. As shown in Tables 5 and 6, page 32, however, the Japanese were drawing steel out of the steel production pipe line supply for ship construction in 1945. As shown on page 75, by the end of the year steel requirements had fallen to the point where inventories were adequate for a considerable period of operation from stocks alone. Therefore, even if the blockade had closed the steel mills down, shipyard activity could have continued for some time so far as raw materials were concerned.

Air attack damage to targets supporting shipyard activity interfered temporarily with production in some of the shipyards but was not as effective as physical damage to the shipyard in bringing about a general reduction in the volume of shipyard activity below the limits established by other factors.

Effects on Shipbuilding of Air Attack Precautions

Comparatively little effort was made to disperse shipyards as a measure of air attack precaution. Though the degree of plant and geographical concentration (shown on pages 5 through 9) was great, it was not as great as in other key industries such as aircraft and motor vehicles. Furthermore, it would not be possible to establish new yards on new sites in a short time even if they were equipped with the machinery from an existing yard. In compliance with the general dispersal directives issued after the first round of urban area attacks, shipyards in the large cities began sending about 10 percent of their machine tools to less vulnerable locations. Only tools not vital to the current volume of shipyard activity were selected and they were only the lighter tools which could be handled without heavy equipment. Wartime shipyard production did not suffer from this program, but inspection of the equipment which had been returned in October 1945 showed that the tools had suffered considerably from weather and lack of maintenance.

Air attack precautions in and about the shipyard were largely confined to personnel shelters and in some instances a limited amount of blast wall protection for vital machinery such as air compressors and rotary electric converters. No large scale protection for machine tools in general was noted except in the few yards where a considerable amount of tunneling had been done to expand the available working areas for yards surrounded by hills. In some instances operating machinery had been installed in these tunnels to gain the protection afforded thereby. The materials and effort involved in these air attack precautions were not sufficient to have detracted sufficiently from the materials and labor available for work on ships

Changes in the Demand for Shipyard Services During the Period of Air Attack

To remain in the war Japan had to get food, coal, and iron from the Asiatic mainland. Therefore, in the face of her continuing loss of

shipping through sinking and isolation in remote regions, she had to continue new ship construction or admit defeat.

On 27 and 30 March 1945 the Twentieth AF dropped more than 1,000 tons of mines and thereafter reenforced the best original fields and sowed new ones on a gradually increasing scale until the end of the war. These mines sank many ships, but their effect on shipyards came in the form of a steeply increased volume of damaged shipping requiring repair.

The last desperate efforts to protect the shipping afloat from the increased direct attack by aircraft and submarine also brought about a sustained effort in the naval coast defense ship construction program in the commercial yards.

The change between 1944 and 1945 in the distribution of the total productive effort applied directly on ships is shown in the following tabulation.

Percent of total work done directly on ships in commercial yards

	1944	1945
Merchant ship construction	54	44
Merchant ship repair	8	12
Naval ship construction	35	39
Naval ship repair	3	5
All work on ships	100	100

Since the 1945 distribution shown above is the average for the entire year it undoubtedly understates the degree of shift that occurred during the last few months of the war. The relative increases in ship repair and naval ship construction reflect a decision on the part of the Japanese that it was better economy to try to keep existing shipping afloat than to spend the same energy producing new ships.

Most of the mines were sown in the Shimonoseki Straits and the approaches to alternate harbors on the Japan seacoast. A substantial number were also sown at various points throughout the Inland Sea. The repair burden imposed by these operations is reflected in the following tabulation of the average monthly value added in merchant and naval ship repair in the commercial yards in these areas:

	1944	1945	Index
Yards on Japan Sea and connecting straits (11 yards)	2,263	2,802	124
Yards on Inland Sea west of Osaka Bay (8 yards)	2,990	3,542	118
All other yards (30 yards)	6,308	3,377	54
Total	11,561	9,721	84

If data for these ratios were available separately for the period following the beginning of mining operation they would undoubtedly have shown even greater relative increases in the shipyards nearest the mine fields.

Conclusions on the Effects of Bombing

The damage inflicted on shipyards by air attacks delivered before the end of June resulted in important reduction in the rate of production in those yards below the declining rate of shipyard activity in the undamaged yards The production loss came as much from the demoralization and disorganization that prevented restoration and recuperation as it did from the destruction of facilities. The urban area attacks caused a considerable increase in absenteeism in the damaged and undamaged yards alike located within those cities.

By the end of the war, production activity had declined below the limits imposed by the materials and labor force available. The only new major factor of change was the damage inflicted in a substantial number of the yards. Direct air attack damage and the consequent disorganization of operations in the damaged yards, may, therefore, be credited with accelerating the decline in the over-all total of shipyard activity to an important degree.

In the summary of damage inflicted by air attack it was shown that in addition to the 17 yards which lost at least 10 percent of their floor space before 30 June, there were 7 major yards which suffered similarly before the end of the war. Together these 7 lost 28 percent of their floor space. A large share of this damage was done by HE bombing By the end of the war there remained only 3 major yards and 22 minor yards which had not lost at least 10 percent of their floor space by air attack. In view of the effect of air attack on production in the yards hit before the end of June, it is reasonably certain that had the war continued shipyard activity would soon have been reduced to a virtual standstill.

The effect obtained from the comparatively minor amount of damage to the shipyards by air attack also suggests that a more intensive application at an earlier stage in the air attack on the home islands might have been an economic use of air power in the destruction of shipping. Had this been done successfully the noose that virtually choked off the Japanese

war effort, namely her shipping collapse, would have been drawn tight sooner and might even have accelerated the final surrender. This would have been particularly effective if such attacks had been directed, as a supplement to the mining campaign, at shipyards located near the mine fields.

APPENDIX 1.—*Facilities and output of 57 Japanese shipyards during the war*

	Value added, all work on ships, 1942-45 (¥1,000,000)	Floor space before attack (1,000 sq. ft.)	Building way, length, 15 August (feet)	Average Employment November 1944 (employees)	Merchant ships delivered, duration (gross tons)	Naval ships delivered, duration (displacement tons)	Value added in conversion and repair 1942-45 (¥1,000)	Floor space destroyed by air attack (1,000 sq. ft.)
Class 1								
1. Nagasaki-Mitsubishi	395.4	4,179	4,039	36,391	353,166	149,110	43,421	974
Total class 1	395.4	4,179	4,039	36,391	353,166	149,110	43,421	974
Class 2								
2. Yokohama-Mitsubishi	267.4	2,371	2,731	14,920	135,315	37,553	44,854	494
3. Kobe-Mitsubishi	231.8	2,384	2,434	23,506	183,915	32,240	32,114	469
4. Tamano-Mitsui	195.0	308	3,403	16,292	304,983	17,450	31,181	...
5 Kobe-Kawasaki	174.7	2,539	3,775	24,048	107,803	52,338	72,263	907
6. Aioi-Harima	133.4	1,043	2,772	14,524	248,296	45,600	30,703	118
Total class 2	1,002.3	8,645	15,115	93,290	980,312	185,181	211,115	1,988
Class 3								
7. Koyagijima-Kawaminami	104.1	409	2,952	13,000	366,977	...	1,157	...
8. Ishikawajima	100.1	1,340	2,441	11,078	131,708	7,620	8,803	800
9. Uraga	100.0	814	2,685	10,920	98,689	23,400	4,009	...
10. Tsurumi-Japan steel tube	91.0	887	3,650	10,457	127,855	35,450	1,684	343
11. Innoshima-Hitachi	85.4	611	2,246	8,483	96,461	1,760	36,504	288
12. Sakurajima-Hitachi	70.7	826	1,266	11,677	97,722	1,906	9,605	413
Total class 3	551.3	4,887	15,240	65,615	919,412	70,136	61,762	1,844
Total major yards	1,949.0	17,711	34,394	195,296	2,252,890	404,427	316,298	4,806
Class 4								
13. Hakodate-Hakodate	38.8	324	1,473	5,316	39,783	2,456	17,996	...
14. Fukahori-Kawaminami	38.0	928	1,181	4,825	134,950	...	996	...
15. Wakamatsu-Mitsubishi	36.3	782	1,805	2,786	117,204	...	720	...
16. Mukaishima-Hitachi	35.4	453	849	1,734	9,340	9,790	13,423	...
17. Matsunoura-Harima	34.3	1,167	1,840	980	136,523	...	...	...
18. Fujinagata	34.3	2,097	1,842	13,319	3,536	32,780	6,344	573
19 Shimonoseki-Mitsubishi	33.3	781	363	3,021	12,950	2,294	16,904	...
20. Naniwa	31.4	126	1,082	2,124	27,810	4,010	3,825	13
21. Hiroshima-Mitsubishi	29.7	1,218	1,476	4,662	48,234	...	...	43
22 Uranosaki-Kawaminami	29.4	410	1,993	4,248	25,937	20,450	...	1
Total class 4	340.9	8,266	13,904	46,015	556,267	71,780	60,208	630
Class 5								
23. Nagoya	24.3	384	1,640	4,825	19,988	...	5 011	333
24. Osaka	22.9	342	1,476	3,897	23,448	28,726	290	102
25. Chikko-Hitachi	22.6	609	...	2,806	...	...	17,775	248
26. Namura	21.9	309	1,089	1,177	28,370	...	4,186	...
27. Kyushu	21.7	244	1,129	1,291	30,858	...	3,728	...
28. Amagasaki-Amagasaki	20.9	139	680	1,876	18,840	...	...	120
29. Dairen	20.0	260	1,125	4,114	29,079	...	9,300	...
30. Konan-Mitsubishi	18.9	384	1,200	5,192	48,928	...	...	...
31. Tokyo	18.7	895	2,362	1,352	93,280	...	...	805
32. Asano-Japan steel tube	17.3	999	673	3,083	10,719	...	10,511	176
33. Kasado	17.2	285	686	1,696	28,422	...	10,345	23
34. Senshu-Kawasaki	16.3	435	2,271	4,604	...	7,630	...	5
35. Nipponkai	15.4	650	678	2,360	9,646	3,750	827	...
36. Niigata	14.6	650	678	2,361	...	6,830	...	...
37. Tagima-Urabe	11.4	196	1,058	1,844	25,105	...	2,342	...
Total class 5	284.1	6,781	16,745	42,480	396,683	46,936	64,315	1,812
Class 6								
38. Osaka-Amagasaki	8.1	48	535	725	7,281	...	511	42
39. Muroran-Hakodate	6.9	280	197	900	1,204	...	5.545	181
40. Hayashikane	6.8	401	1,100	2,884	6,326	...	2.281	...
41. Hora	5.9	42	661	453	7,811	300	2,773	1
42. Tohoku	5.7	91	663	935	6,232	...	1,621	7
43 Hashihama	5.3	67	502	807	10,700	...	219	...
44. Kizugawa	5.2	50	...	301	...	...	4,817	27
45. Kobe-Sanko	4.4	55	394	371	10,844	...	...	22
46. Settsu	4.2	38	426	117	5,460	...	...	1
47. Kanasashi	4.1	101	400	327	3,655	...	...	71
48. Osaka-Sanko	3.8	112	1,017	769	9,163	...	...	...
49. Ohara	3.7	43	200	350	4,150	286	817	29
50. Sanoyasu	3.5	208	839	1,503	23,822	...	1,263	...
51. Kanagawa-Hitachi	2.9	228	592	3,358	8,681	...	...	6
52. Shimizu-Japan steel tube	2.1	183	469	425	2,300	...	...	90
53. Miho	2.0	25	721	361	2,617	...	44	...
54 Osaka-Urabe	2.0	15	298	331	4,506	...	...	...
55. Tokai	1.4	136	350	289	1,562	...	...	...
56. Kanagawa	.2	12	200	45	300	...	...	...
57. Yokohama	.1	10	100	20	150	...	...	...
Total class 6	78.3	2,145	9,664	15,271	116,767	586	19,891	477
Total minor yards	703.3	17,192	40,313	103,776	1,069,717	119,302	144,414	2,919
Grand total all yards	2,652.3	34,903	74,707	299,072	3,322,607	523,729	460,712	7,725

APPENDIX 2.—*Gross tonnage of steel ships over 100 gross tons delivered, by fiscal year by type 1931–45*

Fiscal year	Cargo	Tanker	Ore carrier	Passenger	Ferry	Tug	Fisher	Other	Total
1931	56,455	22,055	.....	3,824	.....	150	1,495	1,325	85,304
1932	28,647	236	1,544	19,766	.....	432	4,191	2,034	56,850
1933	38,559	.....	.....	26,170	.....	620	2,815	3,445	71,609
1934	114,494	19,283	.....	24,688	323	150	5,246	888	165,072
1935	64,799	27,598	.....	14,906		976	2,860	5,374	116,513
1936	147,010	49,277	3,080	54,547		644	21,106	6,846	282,510
1937	307,226	35,622	..	43,663		2,468	42,495	10,908	442,382
1938	265,250	62,946	.....	18,908	107	1,544	52,532	9,357	410,644
1939	222,396	46,938	.....	65,640	2,787	1,657	2,465	1,643	343,526
1940	197,280	3,706	.....	67,283	.....	2,167	3,310	6,070	279,816
1941	174,101	19,098	.....	37,027	.....	2,761	2,847	8,783	237,617
1942	200,063	55,831	33,589	51,064	2,903	1,594	9,725	6,470	361,239
1943	580,271	375,164	113,492	17,757	7,822	2,796	2,842	11,009	1,111,153
1944	988,563	555,387	5,244	29,263	8,553	400	9,677	2,962	1,600,049
1945 (4½ mos.)	175,081	.....	.....	383	2,851	875	1,062	580	180,832
Under construction 15 August	159,176	33,030	10,000	9,000	5,701	1,239	4,258	5,486	227,890

APPENDIX 3.—*Particulars of standard type ships*

Type	Class[1]	Gross tonnage[2]	Dead-weight tonnage[3]	Length (meters) Over-all	Length (meters) Between perpendiculars	Beam meters	Depth (meters molded	Draft (meters) loaded	Normal speed (knots)	Top speed (knots	Machinery Type	Machinery Normal horse-power[4]	Type of Fuel	Cargo capacity (cubic meters) Bale	Cargo capacity (cubic meters) Grain	Number built
1A	C	6,400	9,300	135.90	128 00	17 80	9 80	8 15	10 5	15 0	Reciprocating	3,500	Coal	11,519	12,654	9
1B	C	4,500	6,800	118 00	112 00	15 80	9 10	7 37	11 5	14 0	Turbine	2,400	do.	9,197		15
1C	C	2,700	4,300	97 97	93 00	13 70	7 60	6.35	11 0	14 0	Reciprocating	1,800	do	5,181		33
1D	C	1,900	2,800	87 06	82 30	12 20	6 20	5 33	10 0	12 5	do	1,100	do	3,347		22
1E	C	830	1,265	65 00	60 00	9 50	5 00	4 49	11 0	12 0	Diesel	750	Oil	1,504		14
1F	C	530	700	53 34	50 00	8 40	4 20	3 88	10 0	12 0	do	550	do	955		21
1K	O	5,300	7,900	126 82	120 00	16 50	9 50	7 50	10 0	12 0	Reciprocating	2,100	Coal		8,575	21
1TL	O	10,000	15,200	160 50	153 00	20.00	11 50	9 10	15 0	18 5	Turbine	9,500	Oil		17,100	18
1TM.	T	5,200	7,000	126 81	120 00	16 30	9 00	7 34	11 5	15 0	do	3,600	do		8,667	26
1TS.	T	1,020	1,250	65 07	60 00	9 80	5 00	4 70	10.0	12 0	Reciprocating	950	do		1,375	5
2A	C	6,600	10,200	136.75	128 00	18 20	11 10	7 80	9 5	13 0	Turbine	2,000	Coal	12,838	13,413	124
2D	C	2,300	3,850	91.70	85 00	13 40	7 20	5 85	9 0	11 0	Reciprocating	1,000	do	4,085		80
		877	1,567								Diesel	430				
2E	C	871	1,517	64 30	60.00	9 50	5 45	4 50	7.0	9.0	Hot bulb	380	Oil	1,708	1,809	396
											Reciprocating	400	Coal	1,515	1,612	
2TL	T	10,100	16,000	157 43	148 00	20 40	12 00	9 00	13 0	15.0	Turbine	4,500	Oil		18,970	27
2Tm	T	2,820	4,300	99 00	93 00	13 80	7 30	6 04	9 5	11.5	do	1,100	do		5,184	34
2TE	T	833	1,608	64 30	60 00	9 50	5 45	4 50	7.0	9 0	Diesel	430	do			
											Hot bulb	380	do		1,814	148
3A	C	7,200	11,230	136 85	128 00	18 20	11 10	8 26	12 0	15 5	Turbine	4,500	Coal	11,441	12,205	
3B	C	4,900	6,970	122 85	115 00	16 50	9 50	7 30	14 0	17 5	do	4,500	do	7,440	8,184	
3D	C	3,000	4,700	104 25	98.00	14 30	7 50	6.10	12 0	14 5	do	2,000	do	4,825	5,110	1
3E	C	880	1,565	64 30	60.00	9 50	5 45	4 62	8 0	10 0	Diesel	550	Oil	1,702	1,804	25
		875	1,540						7 5		Reciprocating	500	Coal	1,526	1,594	
3TL	T	10,200	15,467	157 30	150 00	20 00	12 00	9 00	16.0	19 0	Turbine	9,000	Oil		16,785	1
3TE	T	833	1,608	64 30	60 00	9 50	5 45	4 62	9 5	11 0	Diesel	500	do		1,804	1

[1]C = cargo; O = ore carrier; T = oil tanker
[2]100 cubic feet cargo space = 1 gross ton.
[3]Metric ton = 2,204 pounds.
[4]Metric hp. = .98634 English hp. or 75 kg m. sec.

APPENDIX 4.—*Planned construction of merchant ships over 500 gross tons for years 1942–45, as scheduled in plans 1–12 issued by the Navy Technical Bureau*

Date	No. of yards	1942 Cargo and other	1942 Tanker	1942 All construction	1943 Cargo and other	1943 Tanker	1943 All construction	1944 Cargo and other	1944 Tanker	1944 All construction	1945 Cargo and other	1945 Tanker	1945 All construction
15 Dec. 1941[1]	21	362,445	35,850	398,295	273,780	43,740	317,520	211,110	36,000	247,110	62,370	10,000	72,370
5 Feb. 1942[1]	50	364,560	23,500	388,060	495,670	143,300	638,970	583,140	183,700	766,840	441 180	150,950	592,130
3 Mar. 1942[1]	37	456,116	44,200	500,316	539,770	155,100	695,170	576,880	193,700	770,580			
25 Mar. 1942[1]	37	343,210	46,250	389,460	539,250	150,060	689,310	478,100	197,180	675,580	445,980	205,220	651,200
20 Nov. 1942	36				381,850	206,560	591,410	607,620	220,140	827,760	487,440	220,760	708,200
March 1943	55				583,040	235,810	818,880	1,267,180	291,600	1,558,780	844,700	120,000	464,700
December 1943	60				610,070	348,700	958,770	1,419,430	478,680	1,898,110	[2]597,620	[2]241,400	[2]839,020
April 1944	54							1,849,630	781,620	2,631,250	[2]1,126,160	[2]481,600	[2]1,607,760
August 1944	53							1,092,720	873,760	1,966,480	[2]681,400	[2]420,610	[2]1,105,040
November 1944[3]											1,269,230	796,020	2,065,250
February 1945	48										1,265,550	91,080	1,356,630
April 1945 Through 15 August	47										465,485	6,150	471,635
Primary[4]											558,250	8,350	566,600
Secondary[5]											652,080	13,850	665,930

[1]Plans 1, 2, 3 and 4 were prepared and issued by the Ministry of Transportation and Communication.
[2]First 6 months only of 1945.
[3]Details not available. Data presented are from "Report on Present Conditions" issued by the Navy Technical Bureau, November 1944.
[4]First 6 months only of 1945.
[5]First 9 months only of 1945.

APPENDIX 5.—*Monthly yen value input and indexes on merchant shipbuilding*

[Merchant ship yen value input (¥1,000) 7 May 1946]

FISCAL YEAR 1941

Ship type	4	5	6	7	8	9	10	11	12	1	2	3	Total
Cargo	18,246	15,811	14,055	13,257	13,445	12,901	13,002	13,377	13,183	13,388	12,502	12,262	165,729
Tanker	1,410	1,203	1,701	1,865	1,712	1,373	1,699	1,699	3,697	5,137	5,137	6,742	33,375
Ore carrier	...	...	...	...	1,562	1,562	1,562	2,088	2,088	2,436	2,436	2,436	16,170
Passenger	3,827	3,254	3,254	3,634	3,893	3,037	2,701	2,701	2,701	2,701	2,701	2,157	36,561
Ferry	...	...	...	...	714	715	714	715	714	714	...	...	4,287
Fisher	929	490	879	994	904	904	904	742	694	694	794	691	9,522
Tug	660	923	923	834	794	794	794	419	393	393	500	533	7,960
Miscellaneous	951	1,095	940	991	1,345	863	574	574	538	622	2,825	1,443	12,761
Wooden ships	...	...	...	...	...	...	...	...	...	...	...	...	...
New construction, total	26,023	22,776	21,752	21,575	24,369	22,149	21,950	22,315	24,308	26,086	26,795	26,267	286,365

FISCAL YEAR 1942

Cargo	11,061	12,118	13,782	13,209	12,562	12,945	13,464	15,855	20,087	22,070	25,300	24,135	196,588
Tanker	6,659	7,203	6,052	6,052	5,793	5,124	5,902	10,094	10,696	11,911	12,851	16,234	104,571
Ore carrier	3,029	3,029	2,555	2,845	3,006	3,993	3,655	3,307	2,715	4,742	7,284	7,273	47,433
Passenger	1,828	1,828	2,287	2,287	2,287	2,287	2,145	2,145	2,041	1,661	1,084	1,730	23,610
Ferry	...	...	...	...	...	...	...	...	...	...	...	...	...
Fisher	636	636	622	622	278	217	217	201	149	149	225	331	4,283
Tug	699	699	699	722	517	535	337	1,016	911	983	1,072	1,283	9,473
Miscellaneous	271	424	424	394	533	615	1,192	2,447	2,995	2,193	2,193	1,434	15,115
Wooden ships	...	...	...	10	17	86	152	568	1,074	2,138	3,096	4,440	11,581
New construction, total	24,183	25,937	26,421	26,141	24,993	25,802	27,064	35,633	40,668	45,847	53,105	56,860	412,654

FISCAL YEAR 1943

Cargo	21,413	26,874	31,818	36,679	39,127	43,628	46,024	53,522	66,148	91,480	88,115	88,931	633,759
Tanker	18,798	22,426	25,960	27,938	31,619	27,750	27,707	28,841	28,891	38,665	38,185	36,544	353,224
Ore carrier	5,585	6,266	6,814	8,733	9,811	9,828	8,498	6,151	7,684	4,634	1,150	...	75,154
Passenger	1,730	1,730	1,798	1,798	1,798	1,798	1,410	1,410	3,490	3,032	3,032	1,103	24,129
Ferry	...	...	687	687	1,157	1,157	2,192	2,192	1,504	1,504	470	1,052	12,602
Fisher	411	411	411	411	515	563	598	598	829	888	1,372	1,618	8,625
Tug	786	786	535	572	671	697	806	757	594	560	599	315	7,678
Miscellaneous	749	6,441	6,557	3,334	430	315	231	365	365	365	418	334	19,904
Wooden ships	5,533	6,490	8,047	8,620	9,758	13,270	17,805	20,154	20,910	21,150	22,117	22,422	176,276
New construction, total	55,005	71,424	82,627	88,772	94,886	99,006	105,271	113,990	130,415	162,278	155,458	152,319	1,311,451

FISCAL YEAR 1944

Cargo	80,004	72,386	66,597	75,830	75,712	73,198	78,779	81,118	77,905	71,228	69,592	43,647	866,036
Tanker	47,527	52,679	55,246	56,249	55,778	54,263	52,832	38,421	26,876	11,829	5,282	820	457,802
Ore carrier	...	...	...	...	...	...	...	1,443	1,443	1,443	124	124	4,577
Passenger	1,408	2,504	2,509	2,203	3,284	3,592	3,592	2,489	2,489	1,388	1,388	1,388	28,234
Ferry	1,952	1,894	1,894	842	1,544	1,544	702	702	1,543	2,056	1,513	1,513	16,799
Fisher	1,764	1,689	1,451	1,421	1,356	1,080	963	1,123	1,192	807	793	622	14,251
Tug	315	265	265	291	291	291	291	265	265	265	265	235	3,304
Miscellaneous	250	457	457	637	637	637	520	520	314	314	133	133	5,009
Wooden ships	22,163	22,605	21,357	16,852	13,271	12,114	11,177	9,917	8,643	7,312	6,469	5,360	157,240
New construction, total	154,513	154,479	149,776	154,325	151,873	146,719	148,856	135,998	120,670	96,642	85,559	53,842	1,553,252

FISCAL YEAR 1945

Cargo	32,949	25,333	17,910	16,535	10,090	...	...	...	...	...	...	...	102,817
Tanker	797	797	797	797	797	...	...	...	...	...	...	...	3,985
Ore carrier	124	124	124	124	124	...	...	...	...	...	...	...	620
Passenger	307	307	307	307	307	...	...	...	...	...	...	...	1,535
Ferry	1,513	671	671	671	671	...	...	...	...	...	...	...	4,197
Fisher	389	389	389	316	316	...	...	...	...	...	...	...	1,799
Tug	196	232	189	189	167	...	...	...	...	...	...	...	973
Miscellaneous	133	133	133	133	80	...	...	...	...	...	...	...	612
Wooden ships	3,752	2,496	1,812	1,013	387	...	...	...	...	...	...	...	9,460
New construction, total	40,160	30,482	22,332	20,085	12,939	...	...	...	...	...	...	...	125,998

[May 1941 = 100]

FISCAL YEAR 1941

	4	5	6	7	8	9	10	11	12	1	2	3	Year
Cargo	132.1	114.5	101 8	96 0	97.4	93.4	94.1	96.9	97.6	96.9	90.5	88 8	100.0
Tanker	50.7	43.3	61.2	67.1	61.6	49 4	61.1	61.1	132.9	184.7	184.7	242 4	100.0
Ore carrier					77.3	77 3	77.3	103.3	103.3	120.5	120.5	120 5	100.0
Passenger	125.6	106.8	106.8	119.3	127.8	99.7	88.6	88.6	88.6	88.6	88.6	70.8	100.0
Ferry					99.9	100.1	99.6	100.1	99.9	100.1			100.0
Fisher	117.1	61 8	110.8	125.3	113.9	113.9	113.9	93.5	87.5	87.5	87.5	87.5	100.0
Tug	99 5	139 2	139 2	125.8	119.8	119.8	119.8	83.2	59.3	59.3	75.4	80.4	100.0
Miscellaneous	89 5	103 0	88 2	93.4	126.5	81 2	51.5	51 5	50.6	58.5	265.8	135.7	100.0
Wooden ships													
Total	109 0	95.4	91 1	90.4	102 1	92 8	92.0	93.5	101.9	109.3	112.3	110.1	100.0

FISCAL YEAR 1942

Cargo	80 1	87 7	99 8	95.8	91 0	93 7	97.5	114 8	145 4	159.8	183.2	174.8	118.6
Tanker	239 4	259.0	217 6	217 6	208.3	184.3	212.2	363.0	384.6	428.3	462.1	583.7	333.3
Ore carrier	149.9	149.9	126 4	140 8	148.7	197 6	180 8	163.6	134.3	234 6	360.4	359 9	195.6
Passenger	60 0	60 0	75 1	75 1	75.1	75 1	70 4	70 4	87.0	64 5	35.8	56.8	64 8
Ferry													
Fisher	80 2	80 2	78 4	78 4	35.0	27 3	27.3	25.3	18.8	18.8	28.4	41.7	45.0
Tug	105.4	105 4	105 4	108 9	78 0	80 7	50 8	153.2	137.4	148 3	161.7	193.5	119.0
Miscellaneous	25.5	39 9	39 9	37 1	50.1	57 8	112.1	230.1	281.6	206.2	206 2	134 8	118.4
Wooden ships				0 1	0 2	0.9	1 6	6.1	11.5	22.9	33 2	47 6	13.8
Total	101 3	108 7	110 7	109.5	104 7	108.1	113 4	149.3	170.4	192 1	222 5	238 3	144.1

FISCAL YEAR 1943

Cargo	155 0	194 8	230 4	256 8	283 3	315 9	333 2	387 5	479.0	662.4	638.0	643 9	382 4
Tanks	675 9	806 4	933 5	1,004.6	1,137.0	997 8	996 3	1,037.1	1,038.9	1,390.3	1,373.1	1,314.1	1,058.6
Ore carrier	276 3	310 0	337 2	432 1	485.5	486 3	420 5	304 4	380.2	229 3	56 9		338.1
Passenger	56 8	56 8	59 0	59.0	59 0	59 0	46 3	46 3	114 5	99 5	99 5	36 2	66.0
Ferry			96 2	96 2	161 9	161.9	306 8	306 8	210.5	210.5	65 8	147.2	147.0
Fisher	51 8	51 8	51 8	51 8	64 9	71.0	75 4	75.4	104 5	111.9	172 9	203.9	90 6
Tug	118 6	118 6	80 7	86 3	101 8	105.1	121.6	114 2	89 6	84 5	90.3	47.5	98.6
Miscellaneous	70 4	605 9	616.8	313 6	40.5	29 6	21.7	34 3	34 3	34 3	34 3	31 4	156 0
Wooden ships	59 3	69 6	86 2	92 4	104 6	142 2	190.8	216 0	224 1	226.7	237 1	240.3	157 4
Total	230 5	299 3	346 2	372 0	397 6	414 8	441 1	477 7	546 5	680 0	651 4	638 3	458 0

FISCAL YEAR 1944

Cargo	579 6	524 1	482 2	549 1	548 2	530 0	670 4	587 4	564 1	515 7	503.9	316.0	522 6
Tanker	1,709.1	1,894 2	1,986.6	2,022.6	2,005.7	1,951.2	1,899.7	1,381.6	966 4	425.4	189 9	29 5	1,371.7
Ore carrier								71 4	71 4	71 4	6.1	6.1	18 9
Passenger	46 2	82 2	82 2	72 3	107 8	117.9	117 9	81.7	81.7	45.6	45.6	45.6	77.2
Ferry	147 2	265 1	265 1	117 8	216 1	216.1	98.3	98 3	296.0	287 8	211 8	211 8	391.9
Fisher	221 0	212 9	182 9	179 1	170 9	136.1	121 4	141.5	150.2	101.7	99 9	78 4	149.7
Tug	47 5	40 0	40 0	43 9	43 9	43.9	43.9	40.0	40.0	40.0	40.0	35 4	41.5
Miscellaneous	23 5	43 0	43.0	59 9	59 9	59 9	48.9	48 9	29.5	29 5	12 5	12.5	39.3
Wooden ships	237 5	242 3	228 9	180 6	142 2	129 8	119 8	106.3	92 6	78.4	89 3	57.4	140 4
Total	847 5	847 3	627 6	846 7	636 4	614 8	623.8	569 9	505.7	405.0	358.5	225 6	542.4

FISCAL YEAR 1945

Cargo	238.8	183 4	129 7	119 7	73 1								148.9
Tanks	28.7	28.7	28 7	28 7	28 7								28.7
Ore carriers	6.1	6.1	6.1	6 1	6 1								6.1
Passenger	10.1	10.1	10.1	10 1	10.0								10.1
Ferry	211 8	93.9	93 9	93 9	93.9								117.5
Fisher	49.0	49.0	49.0	39 8	39 8								45.3
Tug	29.6	35.0	28 5	28 5	25 2								29.4
Miscellaneous	12 5	12 5	12 6	12 5	7.5								11.5
Wooden ships	40.2	26.8	19.4	10.9	4 1								20.3
Total	168.3	127 7	93 6	84 2	54.2								105.6

[1]Total average of monthly value production equals 100 for wooden ships.

APPENDIX 6.—*United States Strategic Bombing Survey, Military Supplies Branch, 369 Meiji Building*

QUESTIONS FOR COMMERCIAL SHIPYARDS

(Answers to be submitted in English through the Ministry of Transport)

1. Give the following data for each steel ship over 100 tons built in the yard from 1931 through 1945:

1. Name of ship in Romaji.

2. Class (For merchant ships: tanker, cargo, cargo-passenger, collier, tug, dredge, etc. For naval ships: carrier, destroyer, mine sweeper, etc.).

3. Standard type, if any (TL, 2TL, A, 2A, etc.).

4. Gross tons (merchant) or displacement tons (naval).

5. Type of propulsion machinery (turbine, reciprocating, Deisel, etc.).

6. Type of fuel (coal, fuel oil, Deisel oil, etc.).

7. Standard speed.

8. Length.

9. Date keel laid.

10. Date launched.

11. Date delivered.

12. Building way used for construction.

13. Engine maker (company and city, if other than this shipyard).

14. Date engine available (date of completion by this yard or delivery by outside producer).

2. Give the detail and period covered by all production schedules established for the yard from time to time during the war. Details should include: total gross and displacement tonnage for the period, the average days building time, and average days fitting time specified for each class or standard type By whom were the schedules established? Give the dates and details of any revisions of the schedules.

3. Give a breakdown of the work of the yard for each year (fiscal or calendar) 1935–45 in accordance with the items in the attached table.

4. Give the average number of employees for each year 1935–40 and for each month of the years 1941–45.

5. Give the annual tonnage of steel used in shipbuilding during the years 1935–45 and the tonnage on hand for shipbuilding as of the end of each year.

6. Give the number and dimensions of building ways and drydocks and the total amount of floor space devoted to ship construction as of the end of 1935. Give the dates and amount of all major increases and decreases in these items since 1935.

7. For standard type ships built in considerable number give the following:

1. Total weight of the ship at launching.

2. Weight of largest single piece built up before final assembly.

3. Proportion of welding and riveting of hull plates.

8. Show the effects of each air attack in terms of the following:

1. Floor space destroyed.

2. Cranes, drydocks, and building ways damaged.

3. Reduction in manpower (temporary and permanent).

4. Damage to ships in the yard (number of ships and damage in yen).

5. Inventory loss (in yen).

6. Other important factors.

What physical reconstruction was planned and what accomplished?

What measures were taken to continue production?

9. Give the number and total tonnage of merchant ships awaiting repairs and the number and total tonnage of ships in the yard for repairs as of the end of each month, December 1941 to 15 August 1945, classified as follows:

	Cargo	Tanker
Ships over 1,000 gross tons		
Ships 500–999 gross tons		
Ships under 500 gross tons		

NAME OF SHIPYARD ..... YEAR 19 ...

Item and category	Work completed during year				Work in progress at end of year				Millions of manhours
	Number of ships	Tonnage of ships[1]	Value of work completed (1,000 yen)	Cost of material used (1,000 yen)	Number of ships	Tonnage of ships[1]	Value of work completed (1,000 yen)	Cost of material used (1,000 yen)	
1. New construction, merchant									
2. Repair, merchant									
3. Conversion, merchant									
4. New construction, naval									
5. Repair, naval									
6. Conversion and reconditioning, naval									
7. Machinery and products not related to shipbuilding									

Yen value of raw materials on hand at the end of year ..... (1,000 yen)
Yen value of finished components on hand at the end of year ..... (1,000 yen)
[1]Gross tons for merchant ships, displacement tons for naval ships.

UNITED STATES STRATEGIC BOMBING SURVEY

LIST OF REPORTS

The following is a bibliography of reports resulting from the Survey's studies of the European and Pacific wars. Certain of these reports may be purchased from the Superintendent of Documents at the Government Printing Office, Washington, D. C.

European War

OFFICE OF THE CHAIRMAN

1 The United States Strategic Bombing Survey: Summary Report (European War)

2 The United States Strategic Bombing Survey: Over-all Report (European War)

3 The Effects of Strategic Bombing on the German War Economy

AIRCRAFT DIVISION

(By Division and Branch)

4 Aircraft Division Industry Report

5 Inspection Visits to Various Targets (Special Report)

Airframes Branch

6 Junkers Aircraft and Aero Engine Works, Dessau, Germany

7 Erla Maschinenwerke G m b H, Heiterblick, Germany

8 A T G Maschinenbau, G m b H, Leipzig (Moekau), Germany

9 Gothaer Waggonfabrik, A G, Gotha, Germany

10 Focke Wulf Aircraft Plant, Bremen, Germany

11 Messerschmitt A G, Augsburg, Germany { Over-all Report / Part A / Part B }

Appendices I, II, III

12 Dornier Works, Friedrichshafen & Munich, Germany

13 Gerhard Fieseler Werke G m b H, Kassel, Germany

14 Wiener Neustaedter Flugzeugwerke, Wiener Neustadt, Austria

Aero Engines Branch

15 Bussing NAG Flugmotorenwerke G m b H, Brunswick Germany

16 Mittel-Deutsche Motorenwerke G m b H, Taucha, Germany

17 Bavarian Motor Works, Inc, Eisenach & Durrerhof, Germany

18 Bayerische Motorenwerke A G (BMW) Munich, Germany

19 Henschel Flugmotorenwerke, Kassel, Germany

Light Metal Branch

20 Light Metals Industry of Germany { Part I, Aluminum / Part II, Magnesium }

21 Vereinigte Deutsche Metallwerke, Hildesheim, Germany

22 Metallgussgesellschaft G m b H, Leipzig, Germany

23 Aluminiumwerk G m b H, Plant No. 2, Bitterfeld, Germany

24 Gebrueder Giulini G m b H, Ludwigshafen, Germany

25 Luftschiffbau Zeppelin G m b H, Friedrichshafen on Bodensee, Germany

26 Wieland Werke A G, Ulm, Germany

27 Rudolph Rautenbach Leichmetallgiessereien, Solingen, Germany

28 Lippewerke Vereinigte Aluminiumwerke A G, Lunen, Germany

29 Vereinigte Deutsche Metallwerke, Heddernheim, Germany

30 Duerener Metallwerke A G, Duren Wittenau-Berlin & Waren, Germany

AREA STUDIES DIVISION

31 Area Studies Division Report

32 A Detailed Study of the Effects of Area Bombing on Hamburg

33 A Detailed Study of the Effects of Area Bombing on Wuppertal

34 A Detailed Study of the Effects of Area Bombing on Dusseldorf

35 A Detailed Study of the Effects of Area Bombing on Solingen

36 A Detailed Study of the Effects of Area Bombing on Remscheid

37 A Detailed Study of the Effects of Area Bombing on Darmstadt

38 A Detailed Study of the Effects of Area Bombing on Lubeck

39 A Brief Study of the Effects of Area Bombing on Berlin, Augsburg, Bochum, Leipzig, Hagen, Dortmund, Oberhausen, Schweinfurt, and Bremen

CIVILIAN DEFENSE DIVISION

40 Civilian Defense Division—Final Report

41 Cologne Field Report

42 Bonn Field Report

43 Hanover Field Report

44 Hamburg Field Report—Vol I, Text; Vol II, Exhibits

45 Bad Oldesloe Field Report

46 Augsburg Field Report

47 Reception Areas in Bavaria, Germany

EQUIPMENT DIVISION

Electrical Branch

48 German Electrical Equipment Industry Report
49 Brown Boveri et Cie, Mannheim Kafertal, Germany

Optical and Precision Instrument Branch

50 Optical and Precision Instrument Industry Report

Abrasives Branch

51 The German Abrasive Industry
52 Mayer and Schmidt, Offenbach on Main, Germany

Anti-Friction Branch

53 The German Anti-Friction Bearings Industry

Machine Tools Branch

54 Machine Tools & Machinery as Capital Equipment
55 Machine Tool Industry in Germany
56 Herman Kolb Co, Cologne, Germany
57 Collet and Engelhard, Offenbach, Germany
58 Naxos Union, Frankfort on Main, Germany

MILITARY ANALYSIS DIVISION

59 The Defeat of the German Air Force
60 V-Weapons (Crossbow) Campaign
61 Air Force Rate of Operation
62 Weather Factors in Combat Bombardment Operations in the European Theatre
63 Bombing Accuracy, USAAF Heavy and Medium Bombers in the ETO
64 Description of RAF Bombing
64a The Impact of the Allied Air Effort on German Logistics

MORALE DIVISION

64b The Effects of Strategic Bombing on German Morale (Vol. I and II)

Medical Branch

65 The Effect of Bombing on Health and Medical Care in Germany

MUNITIONS DIVISION

Heavy Industry Branch

66 The Coking Industry Report on Germany
67 Coking Plant Report No. 1, Sections A, B, C, & D
68 Gutehoffnungshuette, Oberhausen, Germany
69 Friedrich-Alfred Huette, Rheinhausen, Germany
70 Neunkirchen Eisenwerke A G, Neunkirchen, Germany
71 Reichswerke Hermann Goering A G, Hallendorf, Germany
72 August Thyssen Huette A G, Hamborn, Germany
73 Friedrich Krupp A G, Borbeck Plant, Essen, Germany
74 Dortmund Hoerder Huettenverein, A G, Dortmund, Germany
75 Hoesch A G, Dortmund, Germany
76 Bochumer Verein fuer Gusstahlfabrikation A G, Bochum, Germany

Motor Vehicles and Tanks Branch

77 German Motor Vehicles Industry Report
78 Tank Industry Report
79 Daimler Benz A G, Unterturkheim, Germany
80 Renault Motor Vehicles Plant, Billancourt, Paris
81 Adam Opel, Russelsheim, Germany
82 Daimler Benz-Gaggenau Works, Gaggenau, Germany
83 Maschinenfabrik Augsburg-Nurnberg, Nurnberg, Germany
84 Auto Union A G, Chemnitz and Zwickau, Germany
85 Henschel & Sohn, Kassel, Germany
86 Maybach Motor Works, Friedrichshafen, Germany
87 Voigtlander, Maschinenfabrik A G Plauen, Germany
88 Volkswagenwerke, Fallersleben, Germany
89 Bussing NAG, Brunswick, Germany
90 Muehlenbau Industrie A G (Miag) Brunswick, Germany
91 Friedrich Krupp Grusonwerke, Magdeburg, Germany

Submarine Branch

92 German Submarine Industry Report
93 Maschinenfabrik Augsburg-Nurnberg A G, Augsburg, Germany
94 Blohm and Voss Shipyards, Hamburg, Germany
95 Deutschewerke A G, Kiel, Germany
96 Deutsche Schiff und Maschinenbau, Bremen, Germany
97 Friedrich Krupp Germaniawerft, Kiel, Germany
98 Howaldtswerke A G, Hamburg, Germany
99 Submarine Assembly Shelter, Farge, Germany
100 Bremer Vulkan, Vegesack, Germany

Ordnance Branch

101 Ordnance Industry Report
102 Friedrich Krupp Grusonwerke A G Magdeburg, Germany
103 Bochumer Verein fuer Gusstahlfabrikation A G, Bochum, Germany
104 Henschel & Sohn, Kassel, Germany
105 Rheinmetall-Borsig, Dusseldorf, Germany
106 Hermann Goering Werke, Braunschweig, Hallendorf, Germany
107 Hannoverische Maschinenbau, Hanover, Germany
108 Gusstahlfabrik Friedrich Krupp, Essen, Germany

OIL DIVISION

109 Oil Division, Final Report
110 Oil Division, Final Report, Appendix
111 Powder, Explosives, Special Rockets and Jet Propellants, War Gases and Smoke Acid (Ministerial Report #1)
112 Underground and Dispersal Plants in Greater Germany
113 The German Oil Industry, Ministerial Report Team 78
114 Ministerial Report on Chemicals

Oil Branch

115 Ammoniakwerke Merseburg G m b H, Leuna, Germany—2 Appendices
116 Braunkohle Benzin A G, Zeitz and Bohlen, Germany Wintershall A G, Luetzkendorf, Germany

117 Ludwigshafen-Oppau Works of I G Farbenindustrie A G, Ludwigshafen, Germany
118 Ruhroel Hydrogenation Plant, Bottrop-Boy, Germany, Vol. I, Vol. II
119 Rhenania Ossag Mineraloelwerke A G, Harburg Refinery, Hamburg, Germany
120 Rhenania Ossag Mineraloelwerke A G, Grasbrook Refinery, Hamburg, Germany
121 Rhenania Ossag Mineraloelwerke A G, Wilhelmsburg Refinery, Hamburg, Germany
122 Gewerkschaft Victor, Castrop-Rauxel, Germany, Vol I and Vol II
123 Europaeische Tanklager und Transport A G, Hamburg, Germany
124 Ebano Asphalt Werke A G, Harburg Refinery, Hamburg, Germany
125 Meerbeck Rheinpreussen Synthetic Oil Plant—Vol I and Vol II

Rubber Branch

126 Deutsche Dunlop Gummi Co., Hanau on Main, Germany
127 Continental Gummiwerke, Hanover, Germany
128 Huels Synthetic Rubber Plant
129 Ministerial Report on German Rubber Industry

Propellants Branch

130 Elektrochemischewerke, Munich, Germany
131 Schoenebeck Explosive Plant, Lignose Sprengstoff Werke G m b H, Bad Salzemen, Germany
132 Plants of Dynamit A G, Vormal, Alfred Nobel & Co, Troisdorf, Clausthal, Drummel and Duneberg, Germany
133 Deutsche Sprengchemie G m b H, Kraiburg, Germany

OVER-ALL ECONOMIC EFFECTS DIVISION

134 Over-all Economic Effects Division Report
Gross National Product
Kriegseilberichte
Herman Goering Works
Food and Agriculture
} Special papers which together comprise the above report
134a Industrial Sales Output and Productivity

PHYSICAL DAMAGE DIVISION

134b Physical Damage Division Report (ETO)
135 Villacoublay Airdrome, Paris, France
136 Railroad Repair Yards, Malines, Belgium
137 Railroad Repair Yards, Louvain, Belgium
138 Railroad Repair Yards, Hasselt, Belgium
139 Railroad Repair Yards, Namur, Belgium
140 Submarine Pens, Brest, France
141 Powder Plant, Angouleme, France
142 Powder Plant, Bergerac, France
143 Coking Plants, Montigny & Liege, Belgium
144 Fort St. Blaise Verdun Group, Metz, France
145 Gnome et Rhone, Limoges, France
146 Michelin Tire Factory, Clermont-Ferrand, France
147 Gnome et Rhone Aero Engine Factory, Le Mans, France
148 Kugelfischer Bearing Ball Plant, Ebelsbach, Germany
149 Louis Breguet Aircraft Plant, Toulouse, France
150 S. N. C. A. S. E. Aircraft Plant, Toulouse, France
151 A. I. A. Aircraft Plant, Toulouse, France
152 V Weapons in London
153 City Area in Krefeld
154 Public Air Raid Shelters in Germany
155 Goldenberg Thermal Electric Power Station, Knapsack, Germany
156 Brauweiler Transformer & Switching Station, Brauweiler, Germany
157 Storage Depot, Nahbollenbach, Germany
158 Railway and Road Bridge, Bad Munster, Germany
159 Railway Bridge, Eller, Germany
160 Gustloff-Werke Weimar, Weimar, Germany
161 Henschell & Sohn G m b H, Kassel, Germany
162 Area Survey at Pirmasens, Germany
163 Hanomag, Hanover, Germany
164 M A N Werke Augsburg, Augsburg, Germany
165 Friedrich Krupp A G, Essen, Germany
166 Erla Maschinenwerke, G m b H, Heiterblick, Germany
167 A T G Maschinenbau G m b H, Mockau, Germany
168 Erla Maschinenwerke G m b H, Mockau, Germany
169 Bayerische Motorenwerke, Durrerhof, Germany
170 Mittel-Deutsche Motorenwerke G m b H, Taucha, Germany
171 Submarine Pens Deutsche-Werft, Hamburg, Germany
172 Multi-Storied Structures, Hamburg, Germany
173 Continental Gummiwerke, Hanover, Germany
174 Kassel Marshalling Yards, Kassel, Germany
175 Ammoniawerke, Merseburg-Leuna, Germany
176 Brown Boveri et Cie, Mannheim, Kafertal, Germany
177 Adam Opel A G, Russelheim, Germany
178 Daimler-Benz A G, Unterturkheim, Germany
179 Valentin Submarine Assembly, Farge, Germany
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